Institutional Plan

FY 2000 - FY 2004

October 1999

Brookhaven Science Associates, LLC
Upton, New York 11973

Brookhaven Science Associates

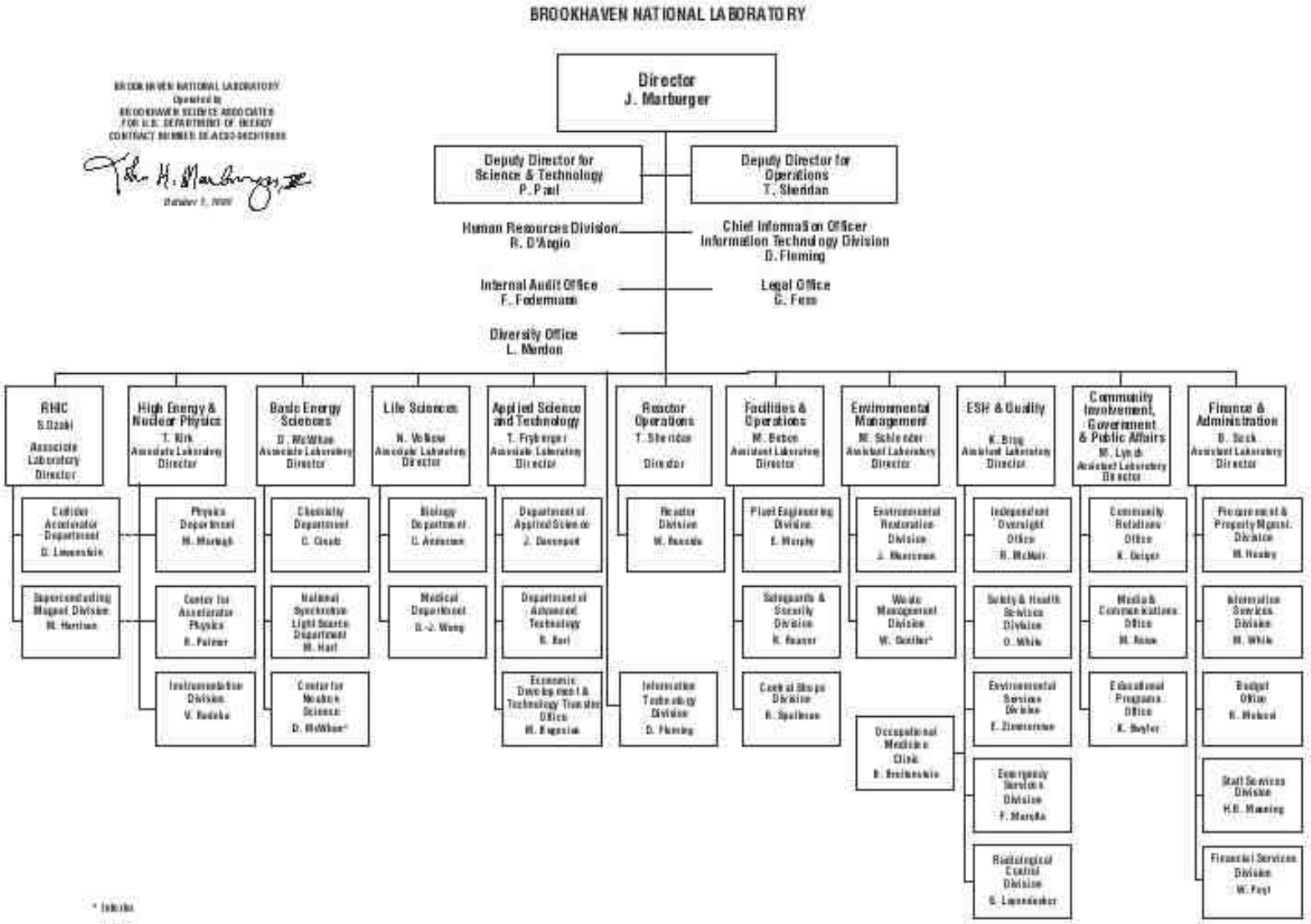
Brookhaven Science Associates is a limited liability corporation with two principal members, the Research Foundation of the State University of New York on behalf of the State University of New York at Stony Brook, and Battelle Memorial Institute Inc. Six other university partners have committed their support to BSA and participate on its Board of Directors.

BSA believes Brookhaven National Laboratory can work with the Department of Energy to produce excellent science in a safe, environmentally clean manner with support and understanding of its many communities. This is a vision in which all Laboratory employees can share and toward which all can work.

BSA further believes in empowering individuals to perform well. People work best who know what is expected of them, who have control over resources needed to do their job, who have the training to do it right and who work in a supportive management context.

BSA believes that, with few exceptions, the community would like to be supportive of BNL, and is committed to provide rapid, consistent, accurate, and comprehensible information to it communities.

Brookhaven National Laboratory



ACRONYMS

AGS	Alternating Gradient Synchrotron	**JGI**	Joint Genome Initiative
ARM	Atmospheric Radiation Measurements	**LEAF**	Laser Electron Accelerator Facility
ATF	Accelerator Test Facility	**LHC**	Large Hadron Collider
BES	DOE Office of Basic Energy Science	**LTR**	DOE Office of Science Laboratory Technology Research
BESAC	Basic Energy Sciences Advisory Committee	**MEL/FS**	DOE Multi-Program Energy Research Facility Services
BHG	Department of Energy Brookhaven Group	**MRI**	Magnetic resonance Imaging
BMRR	Brookhaven Medical Research Reactor	**MRS**	Magnetic Resonance Spectroscopy
BNCT	Boron Neutron Capture Therapy	**NCI**	National Cancer Institute
BNL	Brookhaven National Laboratory	**NE**	DOE Office of Nuclear Energy Science and Technology
BSA	Brookhaven Science Associates	**NIH**	National Institute of Health
CAC	Community Advisory Council	**NN**	Department of Energy Office of Nonproliferation and National Security
CAP	Center for Accelerator Physics	**NNDC**	National Nuclear Data Center
CRADA	Cooperative Research and Development Agreement	**NRC**	Nuclear Regulatory Commission
DOD	United States Department of Defense	**NSF**	National Science Foundation
DOE	United States Department of Energy	**NSLS**	National Synchrotron Light Source
DOT	United States Department of Transportation	**OBER**	DOE Office of Biological and Environmental Research
DP	DOE Office of Defense Programs	**PBM**	Performance Based Management
DUV-FEL	Deep Ultraviolet Free Electron Laser	**PET**	Positron Emission Tomography
EE	DOE Office of Energy Efficiency and Renewable Energy	**PO**	Department of Energy Policy Office
EH	Department of Energy Office of Environment, Safety and Health	**R&D**	Research and Development
EM	DOE Office of Environmental Management	**R2A2**	Roles, Responsibilities, Accountabilities and Authorities
EPA	United States Environmental Protection Agency	**RHIC**	Relativistic Heavy Ion Collider
ES&H	Environment, Safety, and Health	**SBMS**	Standards Based Management System
FACE	Free Air Carbon Experiment	**SC**	Department of Energy Office of Science
FE	Department of Energy Office of Fossil Energy	**SNS**	Spallation Neutron source
FEL	Free Electron Laser	**SPD**	Structural Proteome Database
FTIR	Fourier Transform Infra-Red Spectroscopy		
FUA	Facility Use Agreement	**SPECT**	Single Photon Emission Computed Tomography
GIS	Geographic Information System	**SSI**	Strategic Simulation Initiative
GPE	DOE General Purpose Equipment	**STEM**	Scanning Transmission Electron Microscope
GPP	DOE General Plant Projects	**STM**	Scanning Transmission Microscope
HENP	DOE Offices of High Energy and Nuclear Physics	**SUNYSB**	State University of New York at Stony Brook
HFBR	High Flux Beam Reactor	**TAP**	Tropospheric Aerosol Program
IIMS	Integrated Information Management System	**XAS**	X-ray Absorption Spectroscopy
ISMS	Integrated Safety Management System		

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Executive Summary

Brookhaven National Laboratory is a multidisciplinary laboratory in the Department of Energy national laboratory system and plays a lead role in the DOE Science and Technology mission. The Laboratory also contributes to the DOE missions in Energy Resources, Environmental Quality, and National Security. Brookhaven strives for excellence in its science research and in facility operations and manages its activities with particular sensitivity to environmental and community issues. The Laboratory's programs are aligned continuously with the goals and objectives of the DOE through an Integrated Planning Process. This Institutional Plan summarizes the portfolio of research and capabilities that will assure success in the Laboratory's mission in the future. It also describes how these plans align with the DOE strategic planning and sets forth BNL strategies for our programs and for management of the Laboratory.

The Department of Energy national laboratory system provides extensive capabilities in both world class research expertise and unique facilities that cannot exist without federal support. Through these national resources, which are available to researchers from industry, universities, other government agencies and other nations, the Department advances the energy, environmental, economic and national security well being of the United States, provides for the international advancement of science, and educates future scientists and engineers. Recently, the Department of Energy developed strategic plans (e.g., *The US Department of Energy Strategic Plan, 1997,* http://apollo.osti.gov/policy/doeplan.htm and *The US Department of Energy Comprehensive National Energy Strategy*, http://www.hr.doe.gov/nesp/cnes.html) to assure that it meets the challenges facing the US in the 21st century. It also defined goals, objectives and the portfolio of programs and activities that support these strategies.

The Department is the third largest government sponsor in the US for science and technology, and the Office of Science within DOE establishes the goals for basic science and technology. These goals are "to advance basic research and the instruments of science that are the foundations for DOE's applied missions, a base for US technology innovation, and a source of remarkable insights into our physical and biological world, and the nature of matter and energy" (*DOE Office of Science Strategic Plan, 1999,* http://www.er.doe.gov/).

1.0 Introduction

Brookhaven National Laboratory (http://www.bnl.gov/) is a research institution on Long Island, New York, operated by Brookhaven Science Associates (BSA) (http://www.bnl.gov/bnlweb/BSA.html) under contract with the U.S. Department of Energy. With over 3,000 employees and an annual budget of more than $400 million, the Laboratory is the largest employer in Eastern Long Island. Its 350 buildings occupy a 5,300-acre site on the western edge of Suffolk County's environmentally important Pine Barrens. The Laboratory's primary mission is scientific research in fields requiring unique and complex, often large, facilities, and the design, construction and operation of those facilities for external users as well as for its own scientists. BNL research departments include physics, chemistry, biology, medicine, applied and environmental sciences, and national security and advanced technology. Other departments are devoted to future and ongoing scientific facilities. The largest of these facilities are particle accelerators, synchrotron light sources, and nuclear reactors. More than 4000 scientists from the United States and abroad come to the Laboratory each year to use BNL's facilities and to participate in joint scientific ventures with its staff.

The following recent successes highlight work performed at the Laboratory:

- Completion of the Relativistic Heavy Ion Collider (RHIC), a pair of superconducting accelerators 2.4 miles in circumference designed to accelerate, store and collide gold ions to produce a new form of nuclear matter called the "quark-gluon plasma".
- Successful operation of the "muon g-2" experiment which uses the Laboratory's Alternating Gradient Synchrotron (AGS) and the world's largest superconducting magnet to measure the gyromagnetic ratio of the muon to unprecedented accuracy, probing particle physics beyond the Standard Model. The AGS is the world's most intense source of high-energy protons.
- Development of X-ray imaging techniques at the National Synchrotron Light Source (NSLS), a set of electron accelerators that produce coherent radiation in the X-ray and UV regions of the electromagnetic spectrum. The NSLS provides 60% of the national capacity for synchrotron research, and serves more than 2,500 university, industrial and Laboratory users annually in a wide variety of applications.
- First experimental demonstration of Laser Seeding and High Gain Harmonic Generation that lays the foundation for advanced free electron X-ray lasers and the next generation light source.
- Discovery of addiction-blocking effects of an epilepsy drug, "GVG", by an inter-disciplinary team in chemistry and medicine using Positron Emission Tomography, based on BNL developed cyclotron-produced short-lived isotopes and fast chemistry.
- Assembly of an award winning massively parallel supercomputer optimized for "lattice gauge calculations", the basis for realistic non-perturbative calculations of experimental quantities from the equations of the Standard Model. Further development of scientific computing capability is a priority for the Laboratory.

- Demonstration of a technology for verifying warhead dismantlement in both the United States and Russia. Nonproliferation research and technical support capabilities are a historical strength of the Laboratory.

The BSA contract, which began March 1, 1998, challenges the Laboratory management to produce outstanding science and operate facilities in a safe, environmentally benign manner in harmony with the surrounding community. During the past year, management has made responsibilities more explicit, increased uniformity of requirements and procedures, improved systems for environment, safety, and health management, and increased communications and interactions with external as well as internal constituencies.

2.0 Director's Vision

Brookhaven National Laboratory envisions accelerating progress in the discovery of fundamental knowledge of the structure and interactions of matter, and in linking of this knowledge with the practical technologies needed to address society's most challenging problems.

To realize this vision, the Laboratory must maintain a stimulating research environment that will attract creative scientists and engineers. To this end the Laboratory will continue to devise and develop innovative and powerful research facilities. These will permit scientists from throughout the world to explore the frontiers of their fields, and will foster applications to problems of national significance consistent with the Department of Energy's missions and key objectives. The facilities must include not only the machines for which this Laboratory has become famous, but also the means of processing, visualizing, and interpreting the increasingly voluminous data produced. Complementing these facilities will be a system of recruiting and supporting users that informs new scientific audiences about the rapidly evolving potential of the facilities for their fields, and brings to public attention the importance of fundamental science to contemporary social issues. As the Laboratory enters its second half-century, it must also attend to the conventional facilities housing its users and staff to ensure an environment conducive to the highest levels of performance.

The future of Brookhaven National Laboratory is one of growing complexity. Although the machines and processes that probe microscopic scales spring from basic physics, the applications of these facilities span the entire spectrum of materials, chemical, and biological sciences. Within DOE's missions, the diversity of science and technology that will be pursued in our Laboratory will increase substantially during the next decade. This diversity challenges management, which has responded with increasingly effective and sophisticated management techniques. Management improvements are being driven strongly by heightened societal concern for potentially negative side-effects of the creation and application of new knowledge. The Laboratory strives to manage itself in such a way that the effects of its operations are apparent to its regulators and its communities, and the results of its work add measurable value to the region.

The future of Brookhaven National Laboratory also is one of increasing engagement with people from both within and outside its boundaries. The Laboratory will find ways to share a sense of responsibility and accomplishment with its employees, and to recognize and reward them for their contributions to every aspect of the Laboratory's mission. The Laboratory is extending this shared sense of accomplishment to its communities by openly and sincerely asking for advice, by communicating credibly and comprehensibly, by creating effective mechanisms for resolving issues, and by using our technological resources to bring economic benefit.

The success of Brookhaven National Laboratory depends singularly upon the quality of its people. Only by maintaining the highest standards of excellence in each of

the talents, skills and crafts needed to produce the whole will the Laboratory secure and maintain the position of world leadership to which it aspires. The Laboratory engages in rigorous and candid self-assessment, accepts responsibility for its actions and commitments, vigorously recruits and retains new talent from diverse populations, and encourages continual training and self-renewal of the staff.

3.0 Laboratory Profile

The four key missions of the Department of Energy are Energy Resources, Science and Technology, Environmental Quality and National Security (http://apollo.osti.gov/policy/doeplan.htm). Since its inception 50 years ago, Brookhaven National Laboratory has been a leader in Science and Technology within the DOE national laboratory system, with important contributions to the other mission objectives. Brookhaven strives to maintain a balance between scientific research, the development of new facilities, and operation of existing facilities. BNL's continuing success depends on our ability to maintain alignment of our mission, goals and objectives with those of the DOE. Laboratory staff also engage in extensive collaborations with other laboratories, federal agencies, universities and industries to meet the challenges facing the local, regional and national communities.

3.1 Mission

Brookhaven National Laboratory's role within the DOE laboratory system is to produce excellent science and advanced technology in a safe, environmentally benign manner with the cooperation, support, and appropriate involvement of our many communities. The elements of the Laboratory's mission, which support the four DOE strategic missions, are the following:

- To conceive, design, construct, and operate complex, leading edge, user-oriented facilities in a safe, environmentally benign manner that is responsive to the DOE and the needs of the international community of users.
- To carry out basic and applied research in long-term programs at the frontier of physical, chemical, environmental and life sciences in support of DOE's missions.
- To develop advanced technologies that address national needs and to transfer them to other organizations and to the commercial sector.
- To disseminate technical knowledge, to educate new generations of scientists and engineers, to maintain technical capabilities in the nation's workforce, and to encourage scientific awareness in the general public.

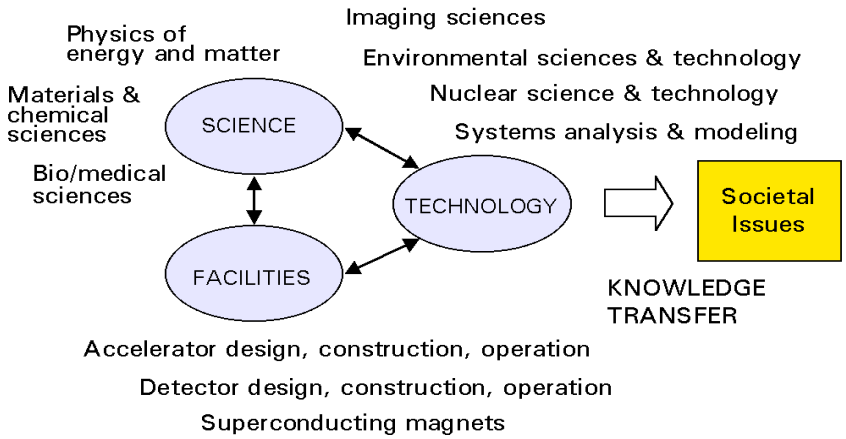
3.2 Core Competencies

Brookhaven National Laboratory is recognized for fundamental discoveries about the structure of matter and energy, the linking of this knowledge to practical technologies, and the transferring of those technologies to address societies most challenging problems (Figure 1). The Laboratory's success is based in the high quality of the scientific and technical staff, the integration of research disciplines, and the technologies and facilities available to staff and users in a broad range of scientific fields.

The Laboratory's breadth of expertise (Table 1 and 2) provides the basis for its contributions to the DOE's missions and focuses on providing extraordinary tools for the pursuit of basic science and technology. In facilities design, construction and operations,

our core competencies are in accelerator and detector design, engineering, and operations, and in the associated technology of superconducting magnets for accelerators. In basic science and technology, our core competencies are in the physics of energy and matter, materials and chemical sciences, biological sciences, environmental sciences and technology, imaging, systems analysis and modeling, and nuclear science and technology.

Figure 1 –BNL Tradition: Integration of Core Competencies and Capabilities



Based on these capabilities Brookhaven hosts an impressive array of facilities:

- For High Energy and Nuclear Physics: The Relativistic Heavy Ion Collider (RHIC), the Alternating Gradient Synchrotron (AGS), Accelerator Test Facility (ATF), Superconducting Magnet Development and Construction Facility.
- For Macroscopic Structures and Imaging: The National Synchrotron Light Source (NSLS), Scanning Transmission Electron Microscope (STEM), Transmission Electron Microscope (TEM), Magnetic Resonance Imager (MRI), Positron Emission Tomography (PET), High Flux Beam Reactor (HFBR), Laser Electron Accelerator Facility (LEAF).
- For Data and Computation: RHIC Computing Facility (RCF), RIKEN teraflop computer, National Nuclear Data Center (NNDC), Visualization Center, Atmospheric Radiation Measurement (ARM) External Data Center.
- For Medical Treatment: Brookhaven Medical Research Reactor (BMRR), Radiation Therapy Facility (RTF), Whole Body Composition Facility.
- For Production: Brookhaven Linac Isotope Producer (BLIP), PET Isotope Production Cyclotrons, Tandem Van de Graaff Facility.

Table 1 - Expertise Fundamental to Brookhaven's Core Competencies
Sciences

High Energy and Nuclear Physics:
- Rare kaon decays
- Muon anomalous magnetic moment
- Exotics and glueball spectroscopy
- Strange matter
- Solar neutrinos
- Nuclear matter in extremes of temperature and density
- QCD phase transitions

Advanced Accelerator Concepts:
- Short wavelength accelerating structures
- Production of coherent radiation free electron laser
- Muon collider and storage ring
- Neutron Sources
- Interlaboratory collaboration on the design and construction of the Spallation Neutron Source

Materials Sciences:
- High Tc superconductivity
- Magnetism
- Surface studies-catalysis, corrosion and adhesion
- Condensed matter theory: metallic alloys and correlated electron systems
- Materials synthesis and characterization with neutron- and X-ray diffraction
- Structure and dynamics
- Defect structure

Chemical Sciences:
- Dynamics, energetics, reaction kinetics on the pico-second time scale
- Thermal-, photo- and radiation- reactions
- Catalysis and interfacial chemistry
- Homogeneous catalysis with metal hydrides
- Porphryin chemistry
- Electrochemistry

Environmental Sciences:
- Global change
- Atmospheric chemistry
- Marine science
- Soil chemistry
- Cycling of pollutants
- Environmental remediation

Medical Science:
- Medical imaging: PET, MRI, SPECT, Coronary Angiography
- Nuclear medicine
- Radionuclides, radiopharmaceuticals, synthesis and application
- Advanced cancer therapies: neutron capture, microbeam radiation, proton radiation, photon-activation therapy
- Mechanisms of oncogenesis

Molecular Biology and Biotechnology:
- Genome structure, gene expression, molecular genetics
- DNA replication, damage and repair
- Structure and function of enzymes, protein engineering
- Plant genomics, biochemistry and energetics
- Solution structure, kinetics and interaction of biomolecules
- Biostructure determination by X-ray and Neutron scattering
- Biostructure determination and mass measurements by electron microscopy

Advanced Scientific Computing and Systems Analysis:
- Atmospheric Transport Modeling
- Risk assessment
- Energy modeling
- Groundwater modeling

Table 2 - Expertise Fundamental to Brookhaven's Core Competencies

Technology Development

Physical, Chemical and Materials Science:

- Advanced instrumentation and devices for precision electronics, optics and microelectronics
- Superconducting and magnetic materials
- X-ray lithography
- Micromachining
- Battery technology
- Permanent magnets
- "Designer" polymers
- Flat planar optical display

Accelerator Technology:

- High-field, high-quality superconducting magnets
- High-power radio-frequency systems
- Ultrahigh vacuum systems
- Advanced accelerator designs
- Accelerator/spallation source applications
- Insertion device development: wigglers and undulators
- High-power, short-pulse lasers

Medical Technologies:

- Biomedical applications of nuclear technology
- Development and production of radionuclides/radiopharmaceuticals
- Development of particle radiation therapies for cancer
- Medical imaging
- X-ray microbeam therapy

Biotechnology:

- Neutron and synchrotron x-ray scattering
- Large scale genome sequencing
- High resolution scanning and cryogenic electron microscopy
- Cloning, expressing and engineering genes
- Metal cluster compounds for electron microscope labels
- Phage displays for probing specific interactions

Environmental and Conservation Technologies:

- Ultra sensitive detection and characterization
- Environmental remediation and mitigation
- Waste treatment
- Disposal of nuclear materials
- Energy-efficiency technologies
- Infrastructure modernization
- Transportation: Intelligent transportation systems, MAGLEV
- Radiation protection

Safety, Safeguards, and Risk Assessment:

- Safeguards, non-proliferation and arms control
- Material and component survivability testing
- Remote sensing of chemical signatures
- Technical support for U. S. policy
- Safety analysis of complex systems
- Probabilistic risk assessment and management
- Human reliability
- Energy-system modeling

3.3 Distribution of BNL Research and Development Portfolio

The DOE Strategic Plan defines the major goals and challenges for the Department's long-term endeavors. The funding for BNL is aligned with DOE's priorities. In FY 2000, the Laboratory's budget is expected to be in excess of $400 M. Figure 2 illustrates the source of expected funds from DOE, other DOE laboratories, and form other federal, state, local and private entities (Work For Others.) The DOE Office of Science provides the major funding for BNL. The Laboratory also receives DOE funds through other DOE laboratories and operations offices. In FY 2000, Oak Ridge National Laboratory will provide significant funds to support BNL's role in the Spallation Neutron Source. Figure 3 shows the distribution of all FY 2000 funds among the four DOE missions. Figures 4 and 5 illustrate the distribution of our direct DOE funds among the DOE mission and the Science and Technology goals.

Figure 2 - FY 00 BNL Funding

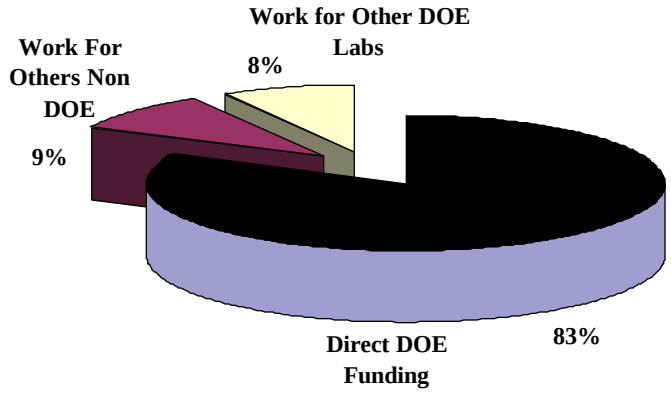


Figure 3 - BNL Mission Footprint

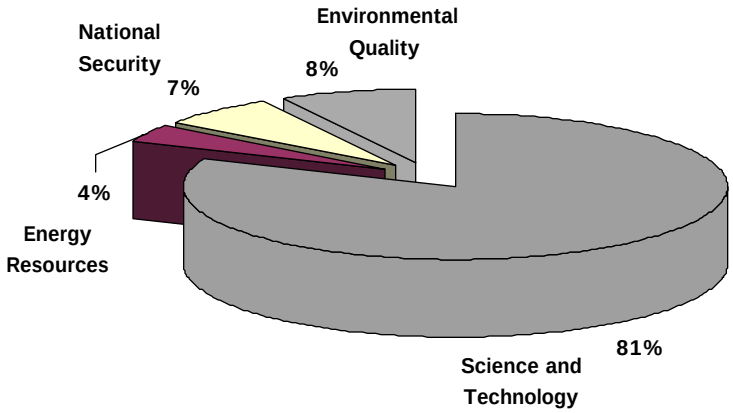


Figure 4 - DOE Supported R&D Mission Profile

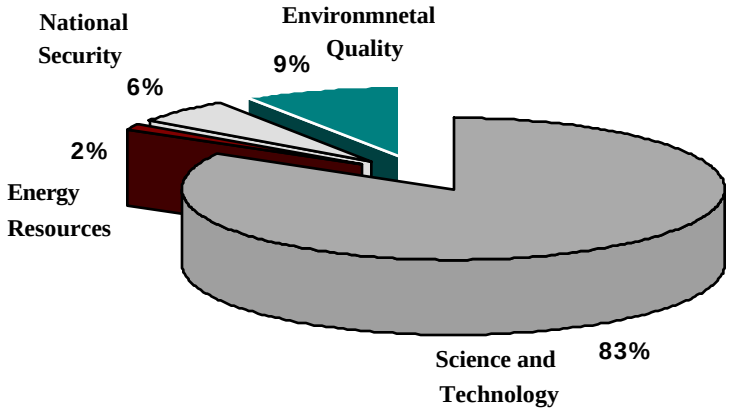
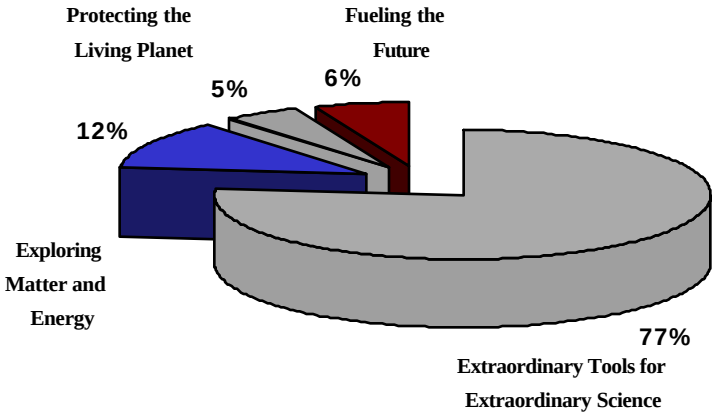


Figure 5 - Science and Technology Mission



3.3.1 Science and Technology Mission

The Laboratory receives 83% of its total DOE funds from the DOE Office of Science and it is a crucial responsibility for BNL to support the DOE-SC goals and strategies. These are summarized in Table 3 (http://www.er.doe.gov). The first four goals focus on the basic science and technology mission of the Laboratories, while the fifth goal articulates the DOE expectations that the Laboratories will achieve and maintain operational excellence as well as scientific excellence. These goals are a basis for BNL's planning and are reflected in the Lab's Critical Outcomes (See section 4). The programs at the Laboratory are distributed among these goals as described below.

Table 3: DOE Science and Technology Mission	
Goals	**Challenges**
Fuel the Future	• Advance the science for development of new and improved fuel. • Explore the science that will lead to advanced generation, storage and transmission of electricity. • Develop the Scientific foundations for cleaner, safe and more efficient fuels.
Protect Our Living Planet	• Improve our scientific understanding of the sources and fate of energy by-products. • Provide a basic understanding of the biology and ecology of energy by-products as they affect humans and the natural world. • Create new science-based approaches to minimize energy by-products and protect the biosphere and human health.
Explore Matter and Energy	• Understand the nature of matter at the most fundamental level. • Explore the evolution and fate of the universe through the fundamental interactions of energy, matter, time and space. • Control complex systems of matter, energy and life.
Provide Extraordinary Tools	• Provide leading edge research facilities and instrumentation to expand the frontiers of the natural sciences. • Advance computation and simulation as critical tools for scientific discovery. • Strengthen the nations institutional and human resources for basic science and multidisciplinary research.
Manage as Stewards of the Public Trust	• Pursue the highest standards of scientific excellence and relevance. • Distinguish facilities and operations as model of safety, health, and environmental protection. • Manage operations and human resources for high performance and efficiency.

Extraordinary Tools for Extraordinary Science: BNL's programs in "Extraordinary Tools for Extraordinary Science" receive 77% of their funds from the Office of Science (Figure 5). We provide cutting edge "Instruments for the Frontiers of Science," including operations of major user facilities, the experimental stations within those facilities, advanced R&D on new accelerator concepts, participation in the Large Hadron Collider Collaboration, and operation of our Imaging Center. In FY 2000 over $100 M will support the operation of the Relativistic Heavy Ion Collider, the nation's newest and second major science facility for nuclear physics.

Two of our Laboratory initiatives and two of our program initiatives (Section 6) build on our capabilities to provide "Instruments for the Frontiers of Science". These are the development of a Deep Ultraviolet Free Electron Laser, research into the concept of a Muon Collider and Neutrino Storage Ring, a third phase upgrade of the National Synchrotron Light Source (NSLS), and Expansion of the Protein Crystallography at NSLS.

The challenge also is to strengthen the nation's institutional and human assets for basic science and multidisciplinary research. In FY 2000 DOE will provide over $15 M in both programmatic and non-programmatic construction to enhance the science facilities and improve the infrastructure at the Brookhaven site. However, the Laboratory is over 50 years old, and needs a significant and sustained increase in infrastructure funds to improve aging facilities, provide adequate services and utilities and adequate space for staff and visitors. In FY 2000 the Laboratory expects an increase in funds for the Science Education Programs, providing exciting opportunities for BNL to play an increasingly significant role in strengthening the nation's future capacity in math and science.

A challenge for BNL is to advance computation and simulation as a critical tool in gathering and interpreting complex data streams for scientific discovery. The Laboratory has committed to increasing its role by providing funds for the Data Intensive Computing Initiative. In collaboration with the University of Stony Brook, BNL has established the Center for Data Intensive Computing. Under the direction of Professor Jim Glimm, this Center has already begun an active program of simulations that assist research in muon collider targets, brain imaging, and cancer treatment plans. Eventually this investment will increase BNL's role in the DOE computational programs. Our programmatic initiatives in initiative in Combustion Related Simulation and Modeling will further increase this participation.

Exploring Matter and Energy: Twelve percent (12%) of the Laboratory's S&T mission focuses on Exploring Matter and Energy. Our R&D portfolio includes the large high energy and nuclear physics experimental and theoretical research programs, basic studies in X-ray and neutron scattering, heavy ion research, support for research at the Laser Electron Gamma Source, condensed matter theory, structural biology, and genome sequencing and analysis.

Brookhaven has outstanding capabilities in specialized genome research and in structural biology. Our scientists are taking the next logical step after the determination of the human genome sequence with the Human Proteome Initiative that aims at determining protein structures expressed from gene sequences in fast throughput procedures. The scope and impact of the Human Proteome Project is comparable to that of the Human Genome Project. DOE, as steward of national laboratories and national synchrotron sources, can play a prominent role as a host for this large-scale enterprise in cooperation with the National Institutes of Health and others. BNL proposes to be a center for cost-effective, large-scale determinations of protein structures by X-ray crystallography. Although support from other agencies such as NIH probably will be required for developing high throughput methods for protein structure determination, this capability will complement DOE initiatives in several areas including biomedical engineering, carbon management, and environmental remediation.

A programmatic initiative in Nanoscience is under development in response to an upcoming interagency initiative complexity. Already the Laboratory is participating in the Complexity initiative (http://www.er.doe.gov/production/bes/nanoscale.html) with a program in correlated electron systems. Our cross-cutting biomedical initiatives would expand the DOE's role in biomedical research by supporting the basic tools and facilities needed to advance current state of knowledge about cancer, aging, substance abuse, and even the effects of space radiation during deep space travel. Several new programs at BNL are connected to NASA's space travel program.

Fueling the Future: Fueling the Future is a "critical theme" for the DOE where the S&T mission includes basic research that will lead to cleaner, safer, more efficient energy systems. In FY 2000 DOE will provide approximately $17 M to support basic research that includes work on "New Fuels" such as, thermal-, photo- and radiation-induced reactions in condensed media, structure-function designs of photosynthetic and catalytic porphyrins, condensed matter theory, and synthesis and structure of conducting polymers.

At BNL basic research in "Efficient Energy Use" includes research on photoinduced molecular dynamics in gas and condensed phase, gas phase molecular dynamics, and catalysis. Our basic research to address the challenge of "Clean and Affordable Power" includes research on superconducting materials, metal-environment interactions, and basic studies of materials by neutron scattering, X-ray scattering, electron spectroscopy, and powder diffraction.

Our new program initiatives in Carbon Management, and Combustion Simulation and Modeling are crosscutting initiatives, related to the DOE challenges for Fueling the Future and Protecting the Living Planet (see Carbon Management at http://www.er.doe.gov/). Both involve basic research to understand "carbon avoidance" and "carbon sequestration." This initiative could provide critical basic information for understanding the regional and global observations that would come form the network of stations proposed in the Environmental Carbon Observatory Initiative.

Protecting the Living Planet: Six percent (6%) of the Laboratory's S&T mission addresses the challenges of Protecting the Living Planet. The DOE will fund over $9M for R&D related to "Prevention and Protection," primarily in the biomedical area to support the research in Boron Neutron Capture Therapy, radiotracer chemistry and neuroimaging, radioisotope production, and high-field magnetic resonance imaging. Our program initiatives in Biomedical Sciences would enhance our capabilities in cellular biology, functional genomics, cancer research and imaging.

The DOE also will support over $4.0 M for BNL programs related to defining the "Impacts of Energy Related By-Products on People and the Environment." These funds support R&D in the Chemistry and Microphysics of the Troposphere, the Free Air Carbon Transfer and Storage experiment, and research on aerosols.

Through the new Laboratory initiative, Trospospheric Aerosol Program (TAP), we propose to coordinate activities of program managers and scientific investigators across the principal national agencies responsible for atmospheric aerosol research and we will conduct

basic research in aerosols on a regional basis. The Environmental Carbon Observatory Initiative would contribute to improved predictions of atmospheric carbon dioxide and climate change, provide a scientific basis for using agriculture, forestry and natural ecosystem to offset carbon dioxide emissions and make possible early warning of large scale, rapid changes in coupled atmosphere-biosphere system.

3.3.2 Energy Resource Mission

(http://www.eren.doe.gov/ and http://www.fe.doe.gov/)

Brookhaven National Laboratory contributes to the DOE mission in Energy Resources. Figure 6 depicts the distribution of funds among the various challenges in Energy Resources. In FY 2000 DOE will direct-fund BNL approximately $5M for R&D in geothermal energy and natural gas storage systems, practical conductors for electric power systems using high Tc oxides, the structure and characterization of battery materials, studies on efficient and affordable buildings, most notably, studies of the
thermal distribution systems in small buildings and support for various efforts in the study of power plant plumes and the national photovoltaic assistance center.

As part of the DOE Nuclear Energy Research Initiative (NERI), BNL has begun a modest program in advanced reactor design.

3.3.3 National Security Mission

(http://www.nn.doe.gov/default.htm)

"Preventing Proliferation" and "Countering Weapons of Mass Destruction" dominate Brookhaven National Laboratory's role in DOE's National Security Mission (Figure 7). We expect a total of $19 M in FY 2000 from the DOE to support BNL's work in nuclear non-proliferation. Over 95% of the monies in non-proliferation support the US-Russian Nuclear Security Programs while the remainder supports BNL's Safeguards Science and Technology Development and the Advanced Systems programs.

Thirty-one percent of the FY 2000 funds will support our programs in "Countering Weapons of Mass Destruction and Terrorism." This is divided almost equally for work in countering nuclear and biological/chemical terrorism, and in protecting critical infrastructure. The majority of these funds will support work in the Initiative for Proliferation Prevention that engages weapons scientist of the Former Soviet Union in non-weapons related research and commerce.

Figure 6 - BNL Energy Resource Mission

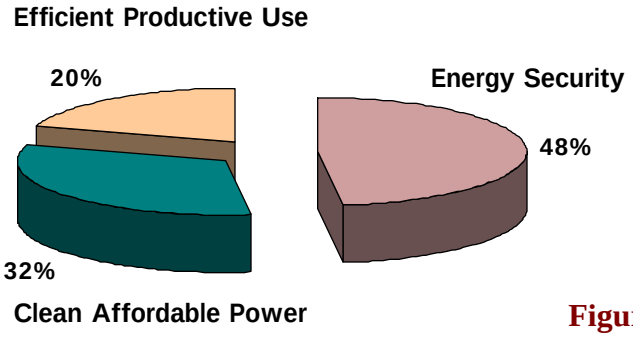


Figure 7 - BNL National Security Mission

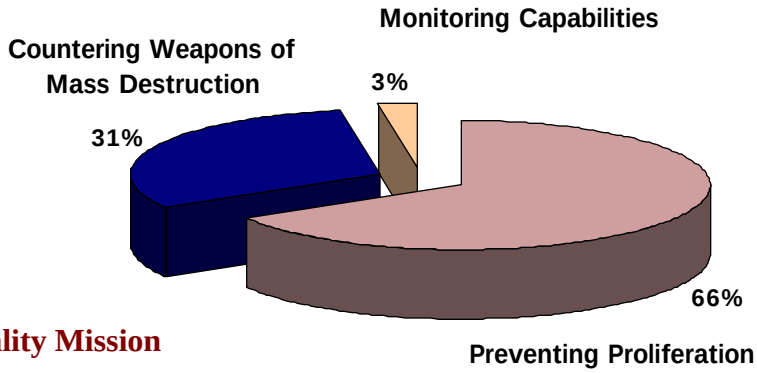


Figure 8 - BNL Environmental Quality Mission

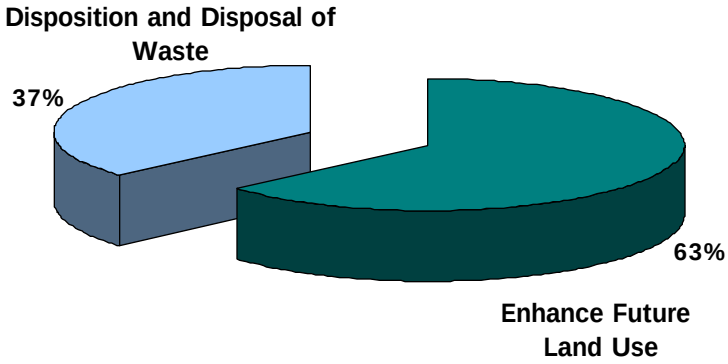
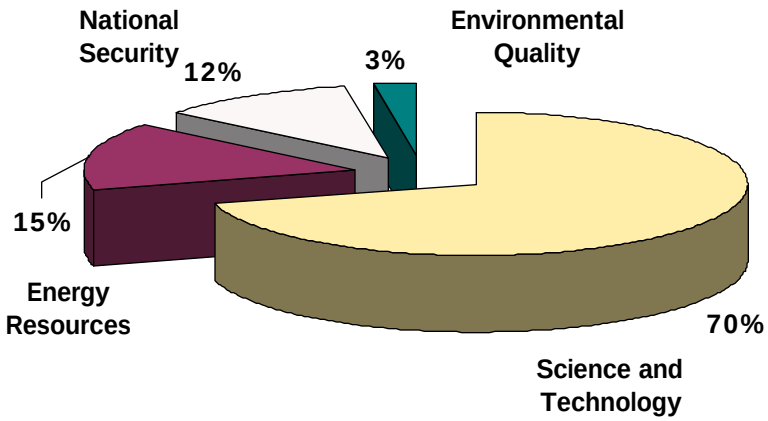


Figure 9 - BNL Work For Others by Mission



3.3.4 Environmental Quality Mission

(http://www.em.doe.gov/)

Our Environmental Quality mission is primarily focussed on efforts to restore the BNL site and to manage radioactive and hazardous wastes. We expect about $31 for FY 2000 primarily from the DOE Office of Environmental Management (EM) for the Disposal and Disposition of Waste and for remedial action programs at the site including work on Brookhaven Graphite Reactor. The Office of Biological and Environmental Research will also fund a program on stabilizing radionuclides with anaerobic bacteria.

3.3.5 Work For Others

The programs at BNL contribute significantly to other DOE Laboratories, federal agencies, institutions and industry. The work done for other agencies derives from our capabilities to meet the challenges of the DOE missions.

In FY 2000 we are projecting a total income of about $70M from Work For Others (WFO), including other DOE Laboratories. Figure 9 shows the distribution of WFO funds among the four DOE missions.

The total projected budget in WFO in the Science and Technology mission is expected to be approximately $51M. Two major activities dominate this S&T profile, funding from Oak Ridge National Laboratory to support our participation in the Spallation Neutron Source, and funding from NASA to support construction of the Booster Application Facility. Other significant activities include support for crystallography at the NSLS, for BNL's Neuroimaging Center, and for the operations of the Scanning Transmission Electron Microscope.

In Energy Resources, funding from others exceeds that provided directly by the DOE. We expect to receive over $1.7 M from other DOE laboratories for work in geothermal energy, the Krakow Clean Coal Fossil Fuel and Energy Efficiency Program, and the Lisbon Project. The Nuclear Regulatory Commission provides more than $8M for work on reactor safety, technical support to the Commission, and support for work on Russian and Ukraine reactors.

The Department of State (DOS) provides the most support in National Security for the program office for the IAEA on international safeguards. The total budget expected from the DOS represents more than 80% of the total WFO budget in National Security.

Only a small percentage of our Environmental Quality Mission is sponsored by Work for Others. The Environmental Protection Agency sponsors a number of programs that deal with technologies for waste management and waste processing.

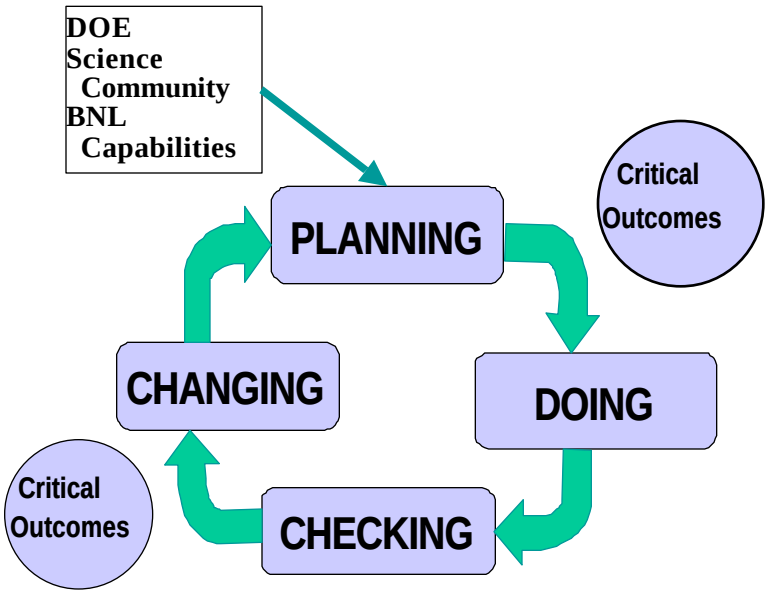
4.0 Performance Based Management

The Laboratory faces the many challenges of a modern research laboratory: a changing science and technology environment, increased competition for funds, and the need to institutionalize management practices and systems that will engender community confidence and assure BNL's continued vitality. These challenges are met by bringing to bear the traditional strengths of the Laboratory in a concerted, focused effort to plan our future and manage our assets. We continue to focus on science and technology that sustains, compliments, and increases our core competencies. We will meet the expectations of the DOE, the scientific community, and our community stakeholders. We will accomplish these goals by continuous alignment of our missions with the DOE missions and national goals, by institutionalizing modern forms of management, and by setting an expectation of "excellence in performance" for every employee.

Under BSA management, the Laboratory has begun a cycle of institutional development through "Performance Based Management (PBM)." This term refers to a cyclic process of performance (Figure 10) that can be described succinctly as: "Plan, Do, Check, Change." The planning process leads to a set of Critical Outcomes, Objectives, and Performance Measures for the Laboratory. These are a direct result of DOE's requirements, expectations and strategic view. Responsibility for accomplishing these is delegated explicitly by the Laboratory Director through a set of formal Roles, Responsibilities, Accountabilities, and Authorities (R2A2's) to each employee, supplemented annually by individual goals. As the work progresses, each manager provides an assessment of the work, which forms the basis for evaluations, plan modifications, and individual compensation decisions.

This "performance cycle" links individual performance to clear objectives that are determined in cooperation with DOE stakeholders, builds assessment into the work

Figure 10 - Performance Based Management Cycle



4.1 Performance Based Management: Planning

The Laboratory's integrated planning system is a key element of our Performance Based Management approach. Figure 11 depicts this process. The planning basis includes the strategic requirements of the Department of Energy, input from the scientific community and our surrounding communities, and incorporates the capabilities of the Laboratory. The Laboratory's internal planning principles that guide integrated planning are the following:

- We will fully align our missions, goals, objectives and expectations with those of our customer, the DOE and other sponsors, and our stakeholders.
- We will build on the strengths at the Laboratory in accelerator-based sciences and technologies, detector and imaging technology and research expertise in a vast array of scientific disciplines.
- We will add critical competencies where they are needed to strengthen our overall strategic position and support the advancement of our programs.
- We will form strong partnerships with other laboratories within the DOE system to meet the research needs necessary to address the challenges of the 21st century.
- We will strive to enhance the transfer of needed technologies to industry and contribute to the education of the future generations of scientist and engineers.
- We will plan and implement improvements to our infrastructure, both the management systems and processes and the physical plant.
- We will develop our human resources through training, recruitment, incentives and a focus on diversity.
- We will fully integrate the expectations of our many communities into the day to day operations of the Laboratory.

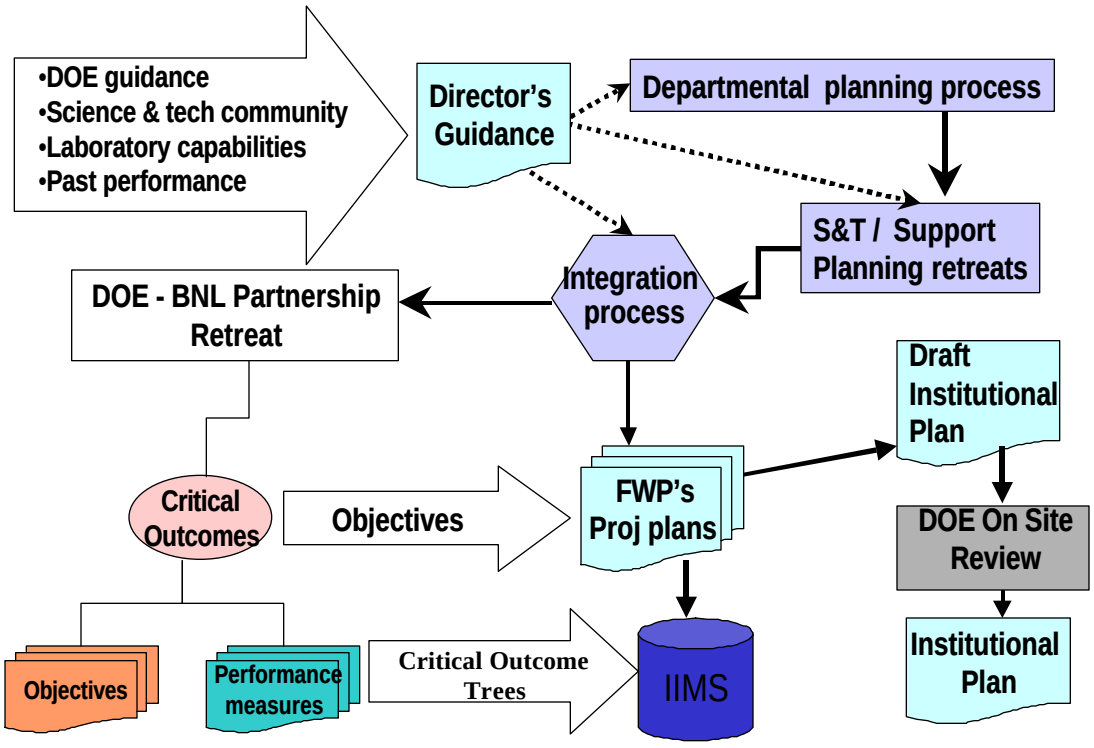
The planning process begins with a set of internal expectations and assumptions. These overarching assumptions are provided below.

- We will assure the quality of and alignment of our science and technology programs through a robust peer review program.
- We will meet the national goals for the Spallation Neutron Source, the Large Hadron Collider and the ATLAS detector.
- We will strive to increase the support from other federal agencies to assure the availability of our facilities to other agencies.
- We will enhance significantly our progress in several research areas and position BNL as a leader in computational science through the Center for Data Intensive Computing and the re-engineering of BNL's computational and information capabilities
- We expect more and larger collaborative efforts in the next three to five years, particularly in the High Energy/Nuclear Physics, Basic Energy Sciences and Biological and Environmental programs.

- BNL will strive to expand its contribution to DOE's missions in Energy Resources, Environmental Quality, and National Security by leveraging our unique assets in user facilities, instrumentation and basic science.
- We will implement Integrated Safety Management by 2000 and achieve ISO 14001 certification for key facilities.
- We will complete clean up activities sponsored by DOE Office of Environmental Management by 2006 and transition the program to the Office of Science.

Several planning processes produce a long-range view for the Laboratory. This view focuses the agenda for the Partners Retreat where BNL, in concert with the DOE, establish Critical Outcomes, Objectives, and Performance Measures. The Critical Outcomes and Objectives are the highest strategic results in programs and management improvements that the Laboratory will deliver to the DOE in three to five years. Achievement of the Outcomes will support and advance the DOE missions, and will demonstrate significant improvements in management of the Laboratory.

Figure 11 - BNL Planning Process



4.2 Performance Based Management: Critical Outcomes

Critical Outcomes and Objectives are an integral part of the planning process, and are consistent with the Performance Expectations of the DOE Office of Science. Further, the Critical

Outcome for Science and Technology will help assure that we continuously align BNL's R&D programs to be fully supportive of the DOE missions and goals. The Critical Outcomes and Objectives for FY 2000 are the following:

1. *Basic Science & Technology:* BNL will deliver innovative, forefront science and technology aligned with DOE strategic goals in a safe, environmentally sound, and efficient manner and will conceive, design, construct, and operate world class user facilities.

   Objectives:

   - Conduct quality research.
   - Assure relevance to the DOE missions and national needs.
   - Successfully construct and operate research facilities.
   - Manage research programs effectively and efficiently.

2. *Communications and Trust:* BNL will be recognized as a community asset, a good neighbor, and a valued employer.

   Objectives:

   - Enhance responsiveness.
   - Create opportunities for stakeholder involvement and participation in Laboratory decision-making processes.
   - Achieve better understanding between internal and external stakeholders
   - Be recognized as a community asset by providing community educational programs for teachers and students and opportunities for the public to visit the Laboratory.

3. *Environment, Safety, and Health Excellence:* BNL will conduct all work and operate all facilities with distinction, fully integrated with and supportive of its science, technology, and clean-up missions, while being fully protective of workers, users, the public, and the environment.

   Objectives:

   - BNL will achieve integration of environmental stewardship into all facets of the Laboratory's mission, and manage programs and operations in a manner that protects the public and the ecosystem.
   - BNL will develop and implement next generation management systems and establish the necessary organizational constructs to ensure continuous improvement in ES&H performance and operations support.

4. *Environmental Stewardship:* BNL will become an exemplary environmental steward through efficient and effective waste management, and by achieving the aggressive clean-up goals contained in DOE's "Path to Closure" for BNL in advance of 2006 in a manner that engages stakeholders in the planning and implementation of the clean-up process.

   Objectives:

   - Reduce the total project cost for the Environmental Restoration program.

- Achieve or accelerate specific milestones in accordance with approved program baselines.
- Ensure wastes derived from current Laboratory activities are managed properly to ensure regulatory compliance and cost efficiency.
- Excess materials inventories will be completely identified, characterization plans approved, treatment/disposal options considered, priorities established, funding allocated and inventories reduced or eliminated.

5. *Leadership:* BNL will be recognized by DOE, users, and BNL staff as the national laboratory with the highest quality leaders and the most effective and efficient management.

   Objectives:

   - Create a poll of talented, diverse, empowered and goal oriented leaders/managers.
   - Maintain the Laboratory's competitive position in the market for required talent, motivate employees to achieve the Laboratory's goals and do so fairly and equitably.
   - Provide a high quality of work environment that enhances BNL's ability to retain and attract an excellent workforce.
   - Implement the Laboratory's Integrated Assessment Program to provide operational, technical and business performance feedback.
   - BSA will provide active corporate involvement to assure success in the management of BNL.

6. *Infrastructure:* BNL will conduct its business and manage Laboratory facilities with distinction, fully integrated with the scientific and technological mission, while being fully protective of workers, public and the environment.

   Objectives:

   - BNL will consolidate mission activities from small, wood frame structures to existing permanent, multi-use research facilities.
   - BNL will effectively and efficiently manage energy usage.
   - Projects will continue to be managed to ensure scope, schedule and costs.
   - BNL will reduce the amount of solid waste sent to landfills through recycling whenever possible.

7. *Business Excellence:* BNL will conduct its business operations with distinction, fully integrated with and supportive of the science, technology and cleanup missions, while being full responsive to the business management needs and expectations of the DOE.

   Objectives:

   - Improve enterprise-wide business management systems in support of world-class research at Brookhaven National Laboratory to provide consistent, cost effective and efficient means of managing the business functions of the Laboratory and provide records of the Laboratory's business/financial transactions for use as a basis for decisions regarding the improvement and enhancement of business operations.

- Identify and review key business processes to provide improved customer service in support of the Laboratory's mission, minimize administrative time and cost and ensure prime contract compliance.
- Develop the institutional-level operating infrastructure needed to underpin an excellent business/information technology infrastructure.

4.3 Performance Based Management: Doing

R2A2s and Goals: The next step in performance based management is the assignment to each individual of a share of the Critical Outcomes through defined roles, responsibilities, accountabilities and authorities (R2A2). The R2A2 ensures that each employee, starting with the Director, comprehends all aspects of their position and its importance in the functions of the Laboratory. The goals capture those elements of an employee's R2A2 that are most relevant to the Laboratory's current needs for improvement. Employee performance is evaluated against these goals.

Standards Based Management (https://sbms.bnl.gov/)*:* BNL is implementing, a Standards Based Management System (SBMS) to ensure that all work is performed according to current policies, regulations, and procedures of the Laboratory, DOE, and other regulators. This computer-based system establishes comprehensive and current documentation of management functions at BNL. The SBMS will help improve operations by providing staff immediate access to policies, standards of performance, requirements, and procedures governing all the work done at the Laboratory. It will also document the processes and systems that underpin Integrated Safety Management at BNL. To speed implementation, BNL's SBMS is being translated from a similar system at Pacific Northwest National Laboratory, operated by BSA's partner, Battelle Memorial Institute, Inc.

4.4 Performance Based Management: Checking and Changing

Self-Assessment: The Critical Outcomes are sufficiently broad to cover all work at the Laboratory. Thus every part of the organization can relate its work to one or more Outcomes. In Performance Based Management, each line organization conducts a Self-Assessment that evaluates organizational performance against desired Outcomes and focuses future efforts on strengths and opportunities for improvement.

Integrated Information Management System: The SBMS helps ensure that all work at BNL is carried out according to current policies, regulations, and standards. The work itself, however, is defined by a series of tasks assigned formally to the various organizations within the Laboratory. Some of these tasks are components of formal projects; others are work elements such as scientific research that do not lend themselves easily to "projectization." All elements, and related information about schedules, budgets, and work categories such as DOE S&T goals, are captured in a Laboratory-wide Integrated Information Management System (IIMS). Based on project management technology, this system amounts to a "work breakdown structure" for the Laboratory, and permits tracking progress as work proceeds. IIMS is accessed through the SBMS and encompasses summary activities, logic and links to other improvement activities and

to detailed project plans that define the tasks required to ensure timely and effective improvement.

Brookhaven National Laboratory is a complex facility with a challenging scientific mission, hazardous materials and equipment, and an alert community of neighbors and stakeholders concerned about environmental and health impacts. It encompasses a number of major user facilities, any one of which could stand alone as a significant research institution. Performance Based Management is a tool known to be effective for driving institutional improvement in such conditions. BSA is committed to implementing PBM at BNL.

5.0 Scientific Program Descriptions and Directions

5.1 Office of Science Programs

5.1.1 High Energy and Nuclear Physics (KA/KB)

(http://www.er.doe.gov/production/henp/henp.html)

Brookhaven will continue its leadership role in both nuclear and high-energy physics. Our objectives in High Energy and Nuclear Physics (HE/NP) include the following:

- Bring the Relativistic Heavy Ion Collider on line on schedule and within budget, begin operations in FY 2000.
- Collaborate in the Large Hadron Collider (LHC) project.
- Maintain progress of the U.S. ATLAS project on schedule and cost.
- Investigate the next generation of collider facilities.
- Continue the overall performance and a high quality selected scientific output of the Alternating Gradient Synchrotron.
- Maintain a strong, in-house staff of researchers to support and enhance the scientific productivity of our user facilities.

Studies sponsored by the DOE, "Nuclear Science: a Long-Range Plan" (February 1996) and "Planning the Future of High Energy Physics" (February 1998) mapped the future direction for the DOE's high energy and nuclear physic basic research programs. Our objectives are consistent with the recommendations of both Committees and follow their recommendations for the highest scientific priorities.

BNL is at the forefront of high energy and nuclear physics, with experimental and theory programs exploring energy and matter, probing for answers to the following key questions:

- What are the fundamental components of matter and what are their interactions?
- What is the physics of matter at extreme states of energy and mass density?
- What is the nature of quark confinement?

DOE's Office of High-Energy and Nuclear Physics sponsors nearly half of BNL's total R&D program. The major elements include the Relativistic Heavy Ion Collider (RHIC), the operations of the Alternating Gradient Synchrotron (AGS) user facility, in-house basic research in particle- and nuclear physics, and, in-house and user research in advanced accelerator concepts and techniques at the Accelerator Test Facility (ATF). The Instrumentation Division and the Information Technology Division provide strong technical support to these activities. Working together, these multi-disciplined units provide a varied and intellectually stimulating environment for research in high energy and nuclear physics.

RHIC (http://www.rhic.bnl.gov/**):** The RHIC construction was completed in 1999, and the physics program using its heavy ion beams will start in FY 2000. RHIC is the world's first dedicated relativistic heavy-ion collider, DOE's investment in the future of nuclear physics. It will have no competition in the world until the Large Hadron Collider begins operating a second, higher energy heavy-ion collider after 2005.

RHIC will be the first facility to produce conditions that have not occurred in the universe since a few microseconds after the "Big Bang." Over 1,000 experimenters from all over the world will work at RHIC, using four complimentary experimental detectors, BRAHMS, PHENIX, PHOBOS, and STAR. Researchers will conduct exciting new experiments in nuclear physics, exploring important aspects of novel phenomena anticipated in this new regime of physics. These include;

- The dynamics of matter in the universe at the time of the "Big Bang,"
- Nuclear physics in the regime of the postulated "quark-gluon plasma," and
- The exotic states of matter that might appear under extraordinary circumstances, such as the "strange matter" that may still exist in the centers of certain white dwarf stars.

On-going collaboration with the RIKEN Institute of Japan will add a unique capability to study of spin-related physics resulting from the collisions of the world's highest-energy polarized protons. This will allow us to determine the distribution of the glue in nucleons and nuclei that binds quarks together. The RHIC science program will be the most exciting and productive basic research program in nuclear physics for the next decade and beyond.

AGS (http://www.rhichome.bnl.gov/AGS/**):** More than 800 users from the United States and abroad performed experiments at the AGS through 1999. The AGS operates in two modes, proton acceleration and heavy-ion-beam acceleration. It is the world's highest intensity proton synchrotron and can accelerate polarized protons to 24 GeV. In the heavy-ion mode, the AGS accelerates heavy ions up to gold (Au). The AGS is the injector for the RHIC, but will still have about 20 hours per day available for a fixed-target user program.

AGS staff also engage in developing specialized experimental equipment, such as particle detectors and beam instrumentation, and collaborate in RHIC heavy ion and spin physics research. The Collider-Accelerator Development scientists are involved in cooperative R&D at other accelerator laboratories and in developing new and novel beam capabilities. Through the Accelerator Applications program, BNL participates in design and construction for off-site projects, such as the Spallation Neutron Source under construction at Oak Ridge National Laboratory, and is constructing a Booster Application Facility for NASA research on space radiation effects.

BNL's distinguished record of productive research and important discoveries in high-energy physics will continue well into the future. The current research will segue into a smaller program focused on experiments of the most compelling interest to the high-energy physics research community. The experiments chosen will exploit the stand-alone beam intensity and cost-effective character of the AGS. Some planned experiments will advance our knowledge of the mysterious phenomenon of CP-violation first discovered at BNL in 1964. Other experiments

will exploit certain rare muon processes that enable researchers to probe for new physics at mass scales and energies beyond those that can be explored with the Large Hadron Collider. These research areas in particle physics will necessitate the continued use of the AGS for about 10 years to fully exploit the scientific opportunities. A protocol has been developed for the proposal, review, DOE approval and funding of prospective future AGS experiments.

Other programmatic advances at the AGS will be in fixed-target nuclear physics. These experiments would continue the use of the AGS for nuclear physics until the planned Japan Hadron Facility becomes operational in 2004.

High-Energy and Nuclear Physics Research : The Physics Department (http://www.phy.bnl.gov/) is home to five experimental groups in nuclear physics, three experimental groups in particle physics and theory groups in both particle and nuclear physics. A small numbers of researchers from the AGS and RHIC Departments supplement this research capability. Experiments at BNL include precision measurement of the muon g-2, search for exotic mesons, and studies of rare kaon decay. With the start-up of RHIC, researchers will begin looking for the quark-gluon plasma and exploring and characterizing new states of matter. Much of the experimental program at the AGS will shift to experiments at the RHIC. BNL experimenters also engage in research at other facilities, such as Fermi Accelerator National Laboratory, Thomas Jefferson Lab, and CERN in Switzerland. BNL is host to the US ATLAS project (http://www.usatlas.bnl.gov/), one of the two detectors for the LHC.

In the theory programs researchers focus on fundamental topics of the electro-weak interaction and of Quantum Chromodynamics. Each group supports the experimental program. The researchers at the RIKEN-BNL Research Center (RBRC) (http://penguin.phy.bnl.gov/www/riken.html/) funded by Japanese science perform theoretical and experimental research in relativistic heavy-ion and polarized proton spin physics providing strong theoretical support to the RHIC heavy ion program and the RHIC Spin Program. Nobelist T.D. Lee directs RBRC and since its founding in 1997, scientists have made significant contributions to the mission in nuclear physics theory. It has recently constructed a powerful 1.0 Tera-flop computer located at BNL ad Columbia University and optimized for lattice gauge calculations. The combined theory effort will put BNL into a prime position to extract the physics from the RHIC experimental data.

BNL will continue to maintain and develop the research staff. Experience over many decades and in many laboratories clearly established that large user facilities could not reach their full scientific potential without dedicated on-site scientists who anchor and collaborate in the scientific program. To this end BNL is making a determined effort to increase postdoctoral appointments.

Accelerator Research and Development (ATF): Built around a 20-MeV electron linac, the Accelerator Test Facility (http://www.nsls.bnl.gov/AccTest/capfiles/CAP.html) is a unique national user facility for experiments in advanced particle accelerator theory, physics, and technology. The Center for Accelerator Physics is the focal point for BNL's work in accelerator R&D and operates the ATF for BNL and for outside users. CAP (http://www.nsls.bnl.gov/AccTest/capfiles/CAP.html) has a strong collaborative effort with other DOE

laboratories and universities exploring the feasibility and impact of a muon collider facility. If technically feasible, the muon collider would represent the most cost-effective way to advance the field beyond the reach of the CERN Large Hadron Collider. A specific early version of a muon collider with neutrino beam capabilities is included in this plan as a Laboratory Initiative.

BNL will continue to operate the Accelerator Test Facility, to advance accelerator science that is crucial to many other fields including materials science, biological and medical science, and other areas using various kinds of particle beams as diagnostic tools.

Other Facilities: BNL will continue to operate the Brookhaven Linac Isotope Producer (BLIP http://www.medical.bnl.gov/medical.htm#BLIP) however at a reduced level. This is due to the reduced availability of proton beams that result from the planned RHIC program. This facility produces important specialized radionuclides for medical use and research. We have submitted a proposal for a 70-MeV high current cyclotron that could serve as a cost-effective national center for isotope production and research and replace BLIP. The nuclear physics program at the National Synchrotron Light Source, the Laser Electron Gamma Source (http://www.legs.bnl.gov/), also will continue well into the future and we will provide quality data on nuclear cross-sections and structures to the scientific and technical communities through the National Nuclear Data Center (http://www.nndc.bnl.gov/**)**.

5.1.2 Basic Energy Sciences (KC)

(http://www.er.doe.gov/production/bes/bes.html)

The DOE Office of Basic Energy Sciences (BES) supports programs at the Laboratory in chemical sciences, materials sciences, geosciences, and energy biosciences. BES supports most of the programs based on synchrotron (National Synchrotron Light Source http://www.nsls.bnl.gov/) and neutron science. The DOE-BES programs represent about 20% of the total programs at the Laboratory, and BNL is a key contributor to the DOE-BES stewardship of neutron and photon sources in the United States.

The BES programs are essential to the Laboratory's goal of achieving strategic growth through interdisciplinary, comprehensive research collaborations. The future of these programs follows from the commitment of the Laboratory to deliver on its Critical Outcome in Basic Science and Technology, including Premier User Facilities.

We will continue as a national leader in basic energy sciences research as demonstrated through publications, peer evaluations, and the nature and quality of collaborations with the academic, industrial, and government sectors. Through innovative research contributions, we will continue to enhance our understanding of materials and to lay the groundwork for future industrial and environmental technologies providing environmentally benign use of fuels and alternative energy sources. The following are the primary strategic objectives for the BES programs:

- Enhance the National Synchrotron Light Source (NSLS) to optimize scientific output.
- Conceive, develop and construct the next generation light source.
- Participate in developing the next neutron source.

- Further strengthen the core program in correlated electron systems by expanding the theory effort and the materials synthesis capabilities.
- Take full advantage of the unique Laser Electron Accelerator Facility (LEAF) to study electron transfer reactions in molecules on short time scales (5-10 picoseconds).
- Expand the catalysis program
- Develop a new interdisciplinary program in nanoscience.
- Integrate disciplines to create research collaborations that provide complete cost-effective solutions to regional and national energy issues.

The National Synchrotron Light Source (NSLS) is the largest user facility in the DOE complex hosting over 2400 users from the United States and abroad each year. Operating for more than 5000 hours each year with an unscheduled downtime of less than 5%, the NSLS presently provides 60% of the total US capacity in synchrotron-based research. Experiments are done over an energy range from the far infrared into the hard X-ray region. R&D at the NSLS have changed the design rules for future synchrotron sources with the development of small gap insertion devices. Aggressive R&D programs enhance the performance of the storage rings, the development of new insertion devices, and new beamline instrumentation to exploit the properties of synchrotron radiation for studies in biology, chemistry, condensed matter physics, environmental science, geophysics, and materials science. The R&D needed to build the next generation photon source, a Free Electron Laser (FEL) operating in the hard X-ray region, is actively pursued at the Accelerator Test Facility and the Deep Ultra-Violet Free Electron Laser (DUV-FEL), which is under construction. We are now planning demonstration experiments of the new science made possible by FELs.

The Basic Energy Sciences Advisory Committee, in November 1997, (BESAC http://www.er.doe.gov/production/bes/BESAC/BESACintro.html) strongly supported the program at the NSLS, and recommended substantial increases in the budget and a continuing investment to keep the facilities at state-of-the-art. The Committee emphasized the large breadth and depth of the research done at the NSLS and the fact that the NSLS hosts more than 50% of the users nationwide. The Committee recommended support for the proposed third phase upgrade projects and funding for the "fourth generation" free electron laser sources.

While BNL continues to enhance the performance of the NSLS storage rings, bring on line new beamlines, and upgrade existing ones, a continuous renewal plan for the NSLS involves improvement projects every decade to keep the facility at the cutting-edge, and provide major enhancements in the accelerator, storage rings and the beamlines. The third phase upgrade plan includes near term improvements, such as the need to incorporate recent advances in optics and monochromators a, fourth stage upgrade may include a full energy injector or use of B-factory technology to increase the flux in the NSLS X-ray ring.

The fourth generation sources will be active particle-photonic devices; accelerators based on the interaction of electron and photon beams or free electron lasers. A BESAC Committee (the Leone Committee) endorsed the concept of joining the best of laser and electron accelerator

technology in the design and construction of a Free Electron Laser (FEL) operating in the hard X-ray region. In the R&D program at the NSLS, BNL is developing the technology and testing the theories of FELs. The national plan calls for conducting the R&D needed to propose construction of a FEL user facility operating in the X-ray region. At the same time the scientific need for the fourth generation sources needs to be demonstrated by experiments on small-scale facilities. BNL is assembling a FEL operating in the deep ultra-violet to do these experiments.

The High Flux Beam Reactor (HFBR): On November 15, 1999 the Secretary of Energy announced his decision to shut down permanently the High Flux Beam Reactor. The unique design and low background for neutron scattering experiments made the HFBR an irreplaceable component of the nations complement of neutron sources. BNL will continue its extensive neutron research program at other facilities such as HFIR and NIST.

Brookhaven also will continue to play a major role in the DOE support of neutron science independent of the HFBR. There are strong programs in the biology, chemistry, and physics. An instrument development group has been assembled in the Center for Neutron Science. The group was poised to complete the thermal guides on H6 and the expanded compliment of instruments at the HFBR if restart had been approved. The group is available to support the HERMES I Spectrometer Development Team based in the chemistry department and the effort in the physics department to collaborate with ORNL in building a state of the art triple-axis spectrometer on the new cold source at HFIR. BNL is involved in several key areas in constructing and operating spallation neutron sources through the design and construction of the accumulator ring and beam transport for the SNS, and through programs in developing detectors and designing a back-scattering spectrometer.

The Center for Neutron Science also is the focal point of an international R&D effort on spallation source target and moderator development. The AGS provides the highest peak beam power of any proton source available today, and a number of studies on liquid mercury targets are on going. A dedicated target and moderator test facility is being assembled on the AGS, and will provide important information needed to develop the next generation of cold neutron spallation sources. A special-purpose spallation neutron source using the AGS is yet another option. With its existing high-peak beam power and reliability, it would be equal or superior as a cold neutron source to any planned or existing spallation source.

Materials Sciences: The principal objective of the material science programs is to study fundamental interactions in solids, and the role of defects in the macroscopic properties of materials. Our Material Science programs include a broad range of research for the Metals and Ceramics, Condensed Matter Physics and Materials Chemistry Teams in the Division of Materials Sciences in DOE Basic Energy Sciences (http://www.er.doe.gov/production/bes/Division.htm#materials). Many of these programs are centered on beamlines at the major neutron and synchrotron user facilities. There also is a new 300keV Transmission Electron Microscope facility and several materials preparation and characterization facilities. Current research areas include high-temperature superconductivity, magnetism, and the properties of surfaces and adsorbed films. The research includes fundamental studies of the electronic properties using angle- and/or spin-resolved photoemission and infrared spectroscopy and of structural and magnetic properties using elastic and inelastic neutron and X-ray scattering

and X-ray absorption spectroscopy. These programs are closely coupled with those in condensed matter theory, which have made significant contributions to the theory of strongly correlated electron systems, X-ray and neutron scattering, low dimensional magnetism, and first principles electronic structure. Research into magnetism includes fundamental studies of lower-dimensional magnetic systems, the interplay between electronic, magnetic, and structural degrees of freedom in giant and colossal magnetoresistance materials, and the structure-sensitive properties of advanced permanent magnet materials. Major advances in understanding high-temperature superconductivity have resulted from the wide variety of measurements made by the combined efforts of many scientists at BNL.

Our goal is to understand the fundamental properties of materials by exploiting the unique facilities and capabilities at the Laboratory, by forming interdisciplinary teams, and by forming strong collaborative efforts. We are pursuing several new directions in materials science programs. Researchers investigate fundamental problem of charge transport in highly correlated electron systems, so-called “bad metals,” by measuring their low frequency dynamics using new infrared spectrometer facilities at the NSLS and comparing the results with models for highly correlated systems developed by the condensed matter theory group at BNL. In collaboration with the University of Connecticut, we are exploring the technique of pulsed laser deposition for the in-situ synthesis of important oxide systems, such as those exhibiting large magne-toresistance effects. The same samples can be studied at the NSLS by high-resolution angle-resolved photoemission, spin-polarized photoemission, X-ray diffraction and magnetic and inelastic X-ray scattering techniques. This wide array of measurements on well-controlled materials can be reliably compared to recent theoretical models.

BNL also continues to explore establishing a program for studying nanostructured polymers that would focus on the structure-property relationship of supramolecular materials, including intrinsic polymers, polymer blends, gels, and organic/inorganic nanocomposites. This would be in collaboration with the State University of New York at Stony Brook (SUNYSB), and EXXON.

A new program for a multi-probe study of functional materials was submitted to the Materials Science Division of BES. It will focus on the combined use of electrons, neutrons and synchrotron X-rays to study the property-determining structure and structural defects of complex functional materials. These materials contain elements for sensing, controlling, processing, actuating, self-diagnosing, feedback, and self-recovery. The systems to be investigated include “colossal” magnetoresistive (CMR) oxides, ferroelectric and piezoelectric oxides and magnetostrictive ferromagnetic shape memory alloys. The scope of the program involves material preparation, property measurements and theoretical modeling. It features cooperative research between the Materials Science Division of BNL's Department of Applied Science and the Physics Department, MIT, and the University of Connecticut.

We also will explore nanoscale structure and structural defects in advanced materials such as high temperature superconductors and high strength permanent magnets using the new transmission electron microscope facility. Computer modeling to explore the role of grain boundaries, vacancies, and impurities in the properties of these materials will complement the experimental program.

Chemical Sciences: Researchers in the Chemical Sciences programs strive to understand and control chemical reactivity. The research areas include the following:

- Solar energy conversion using transition metal complexes and porphyrins as light absorbers,
- Electron transfer reagents and catalysts,
- Electrochemical mechanisms and energy conversion,
- Understanding and improving metal hydride electrodes,
- Characterizing small carbon fragments important in combustion chemistry,
- Understanding single and multiple electron dynamics in intense laser fields,
- Reactions on surfaces and heterogeneous catalysis, including gas-solid and liquid-solid systems, and
- Radiation chemistry as a fundamental science, as a tool for studying fast electron transfer and other chemical reactions, and as a prerequisite to addressing environmental cleanup.

The DOE Chemical and Engineering Sciences Program supports research in the fundamentals of batteries. The Separation and Analysis Program supports research on the atomic structure of liquid-solid interfaces. There is an expanding program on the nucleation dynamics in microparticles and the chemical characterization of ultrafine particles in which researchers explore the aerosols generated by energy production and industrial processes.

In the DOE (http://www.er.doe.gov/production/bes/Division.htm#chemical) Chemical Sciences program, we strive to increase our capability and impact through internal collaboration and partnerships with universities, industry, and other national laboratories. For example, a surface-science/heterogeneous catalysis collaboration the Catalysis and Interfacial Chemistry Effort (CICE http://www.chemistry.bnl.gov/~schretz/catalysisgroup.html), brings together expertise and unique experimental capabilities of surface science, chemical physics, and synchrotron structural capabilities with materials surface science and neutron structural capabilities. In the Brookhaven-based Center for Spectroscopy in Molecular Science, (http://www.chemistry.bnl.gov/jcsms.html) internal collaborations include parallel theoretical and experimental studies exploiting laser pulse shapes to direct chemical reactivity, and external collaborations involving university and BNL expertise to advance understanding of elementary chemical reactions important in hydrocarbon combustion.

Brookhaven has unique resources in its instrumentation, researchers, and ability to bring together interdisciplinary teams. We envision significant advances in the Chemical Sciences program over the next five years. A few are highlighted below.

The Laser Electron Accelerator Facility (LEAF) is a unique facility (http://www.chemistry.bnl.gov/~wishart/crcrintr.html) that provides synchronized picosecond electron and photon pulses. We are proceeding with developing detection instrumentation and improvements to the electron/photon pulse characteristics. LEAF significantly enhances

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Brookhaven's instrumental capability for research in both radiation chemistry and photochemistry.

- LEAF provides a way to the study of the fundamentals of ionization in condensed media on fast time scales. These include reactions at "extreme" temperature and pressure, supercritical fluids, geminate and spur decay, direct ionization and excitation of solutes, "dry" electrons and holes, and ionization in heterogeneous media.
- LEAF provides access to novel excited states. The excited states of radical ions of organic molecules, their chemistry, and their roles in electron transfer reactions will be probed, as will ligand field excited states of transition metal complexes.
- LEAF will advance studies of electron transfer for energy storage and carbon management.

Accurate modeling of combustion chemistry in real systems requires accurate kinetic data for radical-radical reactions over a wide range of temperature and pressure. The Brookhaven facility is already equipped with time-of-flight (TOF) mass spectrometry for determining transient concentrations and product distributions. It is being improved to incorporate highly sensitive spectroscopic probes for short-lived species through the use of frequency modulation spectroscopy with continuous near-infrared laser detection and dispersed fluorescence atomic resonance and resonant ionization probes. This unique capability will broaden and deepen understanding of processes fundamental to combustion, for example, mechanisms of soot formation and direct measurements of ethyl radical reactions.

The primary goal of the Catalysis and Interfacial Chemistry Effort is a molecular-level understanding of chemical reactions that take place at the surface/interface of solids. This understanding can only be achieved by examining how chemical reactivity responds to the interplay of the physical and electronic structure, morphology, and dynamical properties of a material. Fundamental studies of surface interactions and phenomena underlying catalytic activity will be possible in the future with the acquisition of a time-resolved, variable temperature, ultrahigh vacuum (UHV) Scanning Tunneling Microscope. Imaging will have a great impact on understanding metal-on-metal growth, morphology, and reactivity in two-dimensional reactions on surfaces, especially in combination with synchrotron-based studies.

Other structural capabilities essential to future research advances include: use of the NSLS X7B beamline for microcrystals of structurally distorted porphyrins and in-situ powder diffraction studies of functioning catalysts, the role of the 400 MHz NMR in delineating the reactivities of metal-hydride, hydrogen, and carbon dioxide complexes that mediate catalytic and photocatalytic use of hydrogen and carbon dioxide.

Brookhaven will continue to make important advances in instrumentation and advances leading to improved use of synchrotron radiation. We are developing a two-dimensional ion-imaging detector to study surface reactions using vacuum ultraviolet radiation provided by the DUV-FEL. New approaches to attosecond pulse generation will be vigorously explored. The new Single Particle Laser Ablation Time of Flight Mass Spectrometer (SPLAT-MS) is under construction. It will open the door for on-line size and chemical characterization of single particles from 10 nm to 1000 nm. This instrument will be used to study homogeneous nucleation and ambient atmospheric aerosols.

Brookhaven has the capability to advance basic knowledge that is crucial to future technologies for Carbon Management through heterogeneous catalysis and photocatalysis leading to carbon monoxide-hydrogen mixtures (synthesis gas) for use as feedstock, through improved electrocatalysts for fuel cells, through fundamental studies of transition metal and porphyrin promoted carbon dioxide reduction, and contributions to understanding and modeling of combustion.

Energy Biosciences: (http://www.er.doe.gov/production/bes/eb/ebhome.html). In Energy Bioscience we focus on fundamental and applied research directed toward a fuller understanding of the genetic, physiological, and biochemical mechanisms of higher plants (http://bnlstb.bio.bnl.gov/biodocs/plantbio/shanklin.htmlx). Three programs focus on specific biological issues with potential impacts on crop plants. In the first, recombinant DNA technology is used to develop genetic and physical maps of economically important plants, such as maize and cotton. These maps are used widely to describe the position of genes used for improving plants and act as a critical link between classical genetics and genome data. Other experiments focus on understanding and improving lipid modification enzymes. Researchers define how enzymes work and the principles that underlie enzymatic specificity, the property of enzymes that distinguishes them from most chemical catalysts.

Using interdisciplinary techniques including X-ray crystallography, molecular genetics, and classical biochemistry, we will continue to develop methods to alter enzyme specificity for new and desired properties. If successful for crop metabolic engineering, crops could be developed that will accumulate new compounds that can be used as chemical feedstocks. These compounds are alternative and renewable sources of materials currently obtained from non-renewable petroleum sources. The process of directing the evolution of enzymes, being developed using lipid modification enzymes, is an emerging technology that is likely to have implications for other DOE areas such as bioremediation. A key element of our energy bioscience effort is to understand how plants control energy transduced from sunlight into chemical energy. The coupling of biophysical and biochemical pathways require control to optimize energy capture. Knowledge of this process may help engineer more efficient crop plants.

Geosciences (http://www.er.doe.gov/production/bes/geo/geohome.html)
In collaboration with the NSLS, an active program in X-ray microtomography probes the interior of geological samples to determine both fluid flow and mechanical properties in porous media, and studies the distribution of trace elements in plants and insects. In another program researchers study the chemistry of polysulfides in rich marine sediments, the incorporation of sulfur into organic matter, and the effect of this in preserving sedimentary organic matter. These programs involve the search for new petroleum deposits and the role of sulfur, as an environ-mental problem in fuels.

5.1.3 Biological and Environmental Research (KP)

(http://www.er.doe.gov/production/ober/ober_top.html)

The DOE Office of Biological and Environmental Research (OBER) sponsors BNL's biological and environmental research in conjunction with other offices in DOE (BES, NN, and EM), other federal entities (particularly NIH), private foundations, and collaborating industries. These programs extend from the molecular level, to the organism level, to global ecosystems. On the molecular level, basic research in molecular genetics, cell biology, and structural biology provides insights and tools relevant to areas of DOE interest such as the following;

- Elucidating the mechanisms of DNA damage, repair and oncogenesis,
- Analyzing genomes and proteomes,
- Understanding enzymes, interacting systems, microbes, and plants, and the engineering of these for bioremediation or other useful purposes, and
- Developing complex tools for structural biology for use by the research community.

At the organ and whole organism level, we develop imaging techniques, cancer therapies and treatments, medical instrumentation, and radioisotopes for research and medical diagnostics. At the ecosystem level, research includes studies of worldwide carbon fluxes, atmospheric radiation, and the understanding of chemical and physical processes that determine the fate of energy-related pollutants emitted into the atmosphere.

The Laboratory continually aligns its research programs to be consistent with the interests of OBER. Our near term objectives include the following:

- Institute programs on the effects of low dose and low-dose rate radiation.
- Sequence difficult regions of human DNA, generate vectors to improve the production of cDNA libraries enriched for full-length cDNAs, and begin sequencing full-length cDNAs of humans and mice.
- Continue to develop, in partnership with universities and coordinating with other National Laboratory Centers, technology for efficient, high-throughput protein crystallography, to demonstrate the feasibility of a structural genomics component of a Human Proteome Project.
- Continue our research to determine the structures and interactions of biological complexes, improving the methodology, and engineering proteins for useful purposes.
- Continue to improve our user facilities for structural biology, with emphasis on improving efficiency of protein crystallography at the NSLS and ease of access for users.
- Continue to use our unique imaging, nuclear, and synchrotron facilities and capabilities to address issues of human health.

- Develop new scientific and medical tools to advance knowledge about addiction and its treatment, aging, and strategies to improve the life quality in the aging, to develop and understand new therapies for cancer and other diseases.
- Expand our efforts to understand and find solutions for carbon management, atmospheric pollution, and global change.
- Expand our efforts in bioremediation.

Biological Research: BNL has a long and distinguished history of research on DNA damage and repair, both defining the basic biochemistry and genetics and in developing tools for accurate and sensitive measurements (http://bnlstb.bio.bnl.gov/).

A direct result of these strong capabilities in Genome Analysis is developing and implementing the biochemistry and vectors for targeted sequencing of difficult regions by a nested-deletion strategy. This strategy is now used for sequencing highly repeated regions of human DNA. Clones that have proved difficult to sequence by conventional technology will be sequenced at BNL. The single-copy, amplifiable vectors are modified to optimize their usefulness for producing libraries enriched for full-length cDNAs of humans and mice. Full-length cDNAs from such libraries are sequenced accurately and efficiently by the nested deletion strategy. We are testing the application of nested deletions to improve the efficiency of microbial genome sequencing, particularly for rapid filling in of regions of particular interest, in conjunction with sequencing of bacterial genomes and large plasmids having potential for use in bioremediation.

A pilot project in functional genomics began in FY 1998 to test the potential of high-throughput protein crystallography, Proteome Analysis (http://proteome.bnl.gov/) to obtain structures for representatives of protein families for which no structural information is available. Genome and cDNA sequencing projects provide a rich source of information for identifying protein families and obtaining coding sequences for selected proteins. The NSLS is ideal for rapidly and efficiently collecting of X-ray diffraction data. The initial success rate in cloning, expressing, purifying, and crystallizing proteins has been remarkably high, indicating that high-throughput crystallography will be highly efficient at producing a wealth of structural information that will facilitate advances in biomedical science and their commercial exploitation. Additional resources provided from the restructuring of Molecular Biology Research and from our Structural Biology Research efforts allows rapid scale-up of this effort, that has evolved into a collaboration with The Rockefeller University and Albert Einstein College of Medicine.

Many of our research programs use our facilities for Structural Biology to analyze structures and interactions of biologically important proteins and their complexes, including the following;

- Structures of viruses, chromatin and ribosomes,
- Interaction of a viral attachment protein and the receptor on the host cell,
- The outer surface proteins of pathogens (including the antigen used in the vaccine for Lyme disease),

- Interactions in membranes, proteasomes, chaperons and protein folding,
- DNA modifying enzymes,
- Rational drug design for a medically important protease, and
- Understanding and engineering desaturases and hydroxylases, which are potentially useful for producing high-value hydrocarbons or in degrading organic pollutants.

BNL has a unique set of user facilities for Structural Biology including stations at the NSLS for X-ray crystallography of proteins, time-resolved small-angle X-ray scattering and vacuum ultraviolet spectroscopy. The Scanning Transmission Electron Microscope (STEM) is available for high-resolution measurement of shapes and masses of biological molecules and their complexes. The types of information that can be obtained include 3D location of atoms in individual molecules or complexes, the arrangement of molecules in higher-order structures, and the overall shapes and interactions of complexes of molecules. Such information is essential for understanding how biological molecules and structures function.

BNL has an extraordinary combination of strengths in molecular genetics, structural biology, genomics, and biotechnology. This highly interactive research environment is the ideal incubator from which complex user facilities for structural biology can be developed and optimized for the wider research community. Demand for these facilities is strong and growing. We continue to partner with outside groups who invest to upgrade or construct protein crystallography facilities at the NSLS, thereby increasing overall user access.

We want to expand substantially our efforts in the structural genomics for the Human Proteome Project. A bottleneck is the selection of suitable proteins for structure determination, and we are working on a publicly accessible Structural Proteome Database (SPD) to gather the needed information and present it in forms useful for target selection. SPD is designed to provide the information to coordinate efforts among different structural genomics projects, minimizing duplication of effort and maximizing the value of the structural information produced. We are well on the way to developing a 96-well methodology for amplification, cloning, sequencing, expression and testing protein solubility, and soon will be able to produce a steady flow of purified proteins. In collaboration with workers at Rockefeller and Einstein, we are developing techniques to assure that most of these proteins will generate crystals suitable for structure determination. We propose to establish a group to completely re-engineer software for phasing, model building and structure refinement for protein crystallography, to reduce greatly the need for human involvement. Without substantial automation, the process of converting synchrotron data to fully refined structures will soon become a serious bottleneck in high-throughput protein crystallography. Additional scientific staff and expanded collaborations with the University at Stony Brook for research, and training in bioinformatics and computational biology are planned as part of the Center for Data Intensive Computing.

Biomedical Sciences: A hallmark of the Biomedical Sciences programs is our ability to forge strong long-term scientific collaborations between departments, with scientists from other institutions and industry, and with other government agencies. This has enhanced our capa-

bilities and maximized the value of DOE's and BNL's unique resources to problems of public interest.

The Laboratory's Biomedical Sciences programs in imaging, cancer therapies and treatments, medical instrumentation and radioisotope production for medical diagnostics and research are the direct result of our pioneering achievements in radiotracer chemistry and nuclear medicine.

The Imaging programs are integrated into a Brookhaven Center for Imaging and Neuroscience (http://www.chemistry.bnl.gov/bcin.html), sponsored both by DOE and NIH. The National Institute on Drug Abuse funds a NIDA/DOE Imaging Center for Drug Abuse Research. Researchers use the imaging capabilities at BNL, two Positron Emission Tomography (PET) scanners, one 4 Tesla Magnetic Resonance Imager (MRI), and one Single Photon Emission Computed Tomography (SPECT) scanner, to

- Characterize the effects of drugs in the brain and investigate the molecular changes underlying addiction and their relationship to function and treatment,
- Investigate molecular changes underlying normal aging and their relationship to motor and cognitive performance, and
- Investigate the actions of therapeutic drugs in the human body to determine mechanisms, to optimize their beneficial effects, minimize toxicity, and to expedite the introduction of new drugs into the practice of health care.

In a program supported by both DOE-NE and DOE-OBER, BNL supplies Medical Isotopes for diagnosis, and develops and evaluates radiopharmaceuticals for diagnosis and treatment of cancer (http://www.medical.bnl.gov/medical.htm#RAD).

Work at the NSLS in Medical Instrumentation continues to result in the development of new radiation treatments based on the delivery of very narrow beams of high doses of irradiation to treat malignant brain tumors. These narrow beams deliver a significantly higher dose of radiation without the problems of necrosis encountered with conventional treatments. The NSLS also is being used for Computed Tomography (CT) scanning mammography and bronchography. Its high flux can generate a monochromatic beam with a considerably improved contrast gradient for structures with different densities than those obtained with conventional X-ray machines. At the Whole Body Counting Facility, researchers are investigating changes in the body's elemental composition associated with aging, obesity, and disease.

The goal for Biomedical Research at BNL is to add significant new knowledge to the solution of major public health problems in the areas of addiction, cancer, aging, and neurodegenerative diseases. This will be achieved by the following:

- Attracting and retaining world class scientific talent,
- Adding new instruments and facilities to advance BNL's capability,

- Optimizing the value of the DOE core programs to the public by facilitating collaborations with other institutions and access to BNL's resources by other government and private agencies,
- Pursuing new sources of funding including NIH, NASA, and other government agencies, industries and private foundations, and
- Educating and training the next generation of biomedical scientists by inviting students to participate in research in our laboratories.

We will develop several programmatic initiatives over the planning period that will consolidate existing programs as well as integrate other organizational strengths into the bio-medical efforts.

The short term objectives of Boron Neutron Capture Therapy (BNCT) program are to assess the toxicity of treatment, assess the efficacy for glioblastoma multiforme, optimize strategies for delivering boron-10 to the tumor, and optimize destruction of the tumor while minimizing the effects on normal brain tissue. Over the longer term, we will assess the potential use of BNCT for other types of cancer such as melanoma and head and neck cancers, assess the potential benefits of treatment combinations with BNCT and assess the utility of BNCT in bone marrow irradiations.

Currently, BNCT treatments rely on the neutron beam from the Brookhaven Medical Research Reactor (BMRR). The future of the BMRR depends on whether the DOE will provide adequate funding to operate the facility. We recently participated in a workshop on the potential use of accelerators for BNCT sponsored by the DOE. The expert consensus was that there is a need for a high current prototype accelerator for testing several aspects including target design, heat removal and beam characteristics. BNL is the primary candidate for such a "test bed" using the tandem accelerator that currently is being installed at the Laboratory.

If BNCT is shown to be an effective treatment for cancers, the ability to provide routine clinical treatment will depend on access to neutron sources other than those provided by a nuclear reactor. Accelerator technology, if it is shown to be an effective alternative, will make BNCT clinically relevant since it will be possible to have accelerators at major medical centers.

In imaging, we plan to expand our programs to evaluate the function of brain-related genes, and gene therapies. We also will increase the role of the Laboratory in developing medical instruments with unique medical applications, such as accelerators as alternative source of neutrons, small synchrotrons, and detectors with better imaging properties.

The development of the Center for Data Intensive Computing (http://www.cdic.bnl.gov/) will further the success of our Imaging Center for Neuroscience. This Data Center will provide us with critical capabilities, ranging from integration of information derived from PET or Magnetic Resonance Spectroscopy images with those derived from Magnetic Resonance Imaging spatial images, to ways to represent graphically, information derived from the imaging studies (e.g., functional coherence maps).

Environmental Program: Three BNL Environmental Process programs support the DOE goals in global climate change and carbon management. In the DOE Free-Air Carbon Dioxide Enrichment (FACE) program we develop and use facilities that expose ecosystems to elevated levels of CO_2 in a controlled fashion. FACE sites are supported as part of our Terrestrial Carbon Cycle research. Atmospheric radiation and the factors that control it are measured under the DOE Atmospheric Radiation Measurement (ARM) program. BNL uses data from the Southern Great Plains in Oklahoma to produce new parameterization for the Direct and Indirect Effects of Aerosols and to improve the treatment of Cloud Microphysics in Global Circulation Models. Novel radiation measurement systems are developed and used on the ARM Tropical Western Pacific Island sites and aboard oceanographic vessels participating in international programs investigating the region. BNL contributes to the ARM infrastructure by providing mentors for several observational systems. ARM's science programs require data collected by other measurement programs, and many of these data sets are acquired, managed, and stored at BNL's ARM External Data Center.

BNL researchers in the Chemistry and Microphysics of the Troposphere program strive to establish an understanding of the chemical and physical processes that determine the fate of energy-related pollutants emitted into the atmosphere. The Laboratory is taking a leadership role in the development of a new DOE Tropospheric Aerosol Program (TAP) which will contribute critical data on the processes that contribute to the formation of atmospheric aerosols and their effect on air quality.

The focus of our Environmental Remediation program is to understand how microbes can be used to reduce the concentration of environmental radionuclides and heavy metals. Brookhaven has a long history in bioremediation and holds a patented process. In the Natural and Accelerated Bioremediation Research (NABIR) program, genome sequencing is being applied to study the important features of a Clostridium strain potentially useful for precipitating uranium. Work has begun on "Transformation of Heavy Metal Contaminants in Sulfate-Reducing Sub-surface Environments: The Role of Thiolated Compounds and Hydrogen Sulfide." Remediating soils and marine sediments contaminated by radionuclides and toxic metals are challenging because, unlike most organic pollutants, these cannot be degraded. In the Environmental Science Program, researchers study the chemical modifications of radioactive waste caused by nitrogen dioxide and peroxynitrite.

With global climate change and carbon management assuming national priority, three BNL programs will have new emphasis within DOE; Free-Air Carbon Dioxide Enrichment (FACE), Chemistry and Microphysics of the Troposphere, and Atmospheric Radiation Measurement (ARM).

In the next three to five years BNL will expand its participation in environmental research. For example, the Environmental Carbon Observatory would combine FACE experiments with carbon dioxide eddy-flux measurements in a worldwide network, and integrate measurements of marine carbon flux into modeling of global climate change. We also propose to study the basic genomics and physiology of a microorganism that sequesters CO_2 as calcium carbonate in the ocean.

Our environmental studies will profit from Center for Data Intensive Computing at BNL. One aspect of our proposed program is to address the management and integration of large disparate data sets into a continuum of local to global models of climate prediction.

In Environmental remediation, our specialty is bioremediation of soils and sediments contaminated by metals. We plan to grow this area particularly in developing, understanding, and engineering microbes for bioremediation.

5.1.4 Office of Science Education Programs (KX)

The Laboratory has a long-standing commitment to future generations. Our role (http://www.scied.bnl.gov/) in DOE's educational objectives is the following;

- To enrich the training of the nation's future scientists and engineers, and help build the capacity of undergraduate institutions,
- To support undergraduate and pre-college institutions in providing educational and career pathways in mathematics, science, and engineering for a diverse population of students, and
- To promote professionalism in pre-college mathematics, science and technology (MST) teaching, and systemic change in pre-college learning standards and teacher preparation.

Undergraduate interns develop skills through research with BNL staff mentors who provide a first-hand exposure to science and the scientific community. These programs include summer/academic semester research appointments for about one hundred undergraduates annually, and a new Community College Institute that will accommodate about thirty students each summer.

Topical Conferences, Workshops, or Summer Schools offer educational enrichment in areas where the Laboratory has unique capabilities. These include a Nuclear Chemistry Summer School, Undergraduate Mini-Semester, and two Summer Institutes for High School Students, and a major Conference on Undergraduate Materials Science Education. Each activity is based on one or more aspects of BNL’s research. This year, roughly one hundred fifty people, from university faculty to ninth graders participated in these programs.

Teacher Enhancement Programs involve secondary teachers in research at the Laboratory. Immersion workshops engage primary teachers in learning scenarios simulating actual processes involved in our research. These efforts are largely supported by other agencies and are conducted in collaboration with schools of education to help focus outcomes on improved pedagogy. In NSF’s MST Program, for example, BNL is a key contributor to an educational reform effort that will reach over one thousand kindergarten through sixth-grade teachers.

Outreach and Resource Programs that support schools, faculty and teachers have been severely scaled down. Through voluntary effort and cooperation with other BNL organizations, it has been possible to develop collaborations between the Laboratory and eight local pre-college educational organizations, conduct teacher workshops, offer special student events, and provide

technical assistance to school districts. These efforts reach hundreds of teachers and parents and over one thousand students annually.

Undergraduate Programs remain a principal focus of DOE-supported activities and the anticipated funding increases will allow us to significantly increase student internships during the academic year, offer a program for student-faculty research teams at major laboratory facilities, and establish new topical institutes in areas, such as materials science.

The objective of these initiatives is to build capacity at participants' home institutions. The longer-term objective is to help establish a Long Island Consortium for Undergraduate Research. This would link programs offered by the educational community, the industrial community, and the Laboratory to help provide research-based training to prepare and retain Long Island's top students for the local high-tech job market.

Teacher Enhancement Programs will be expanded with growing support from DOE. For secondary teachers we will restore both our summer research participation program and in-service course series. We also will work with the teacher education community to develop a paradigm for incorporating research participation in Middle School Teacher Education programs. This will be supported by research internships for undergraduate and graduate education majors.

Under Outreach and Resource Programs, we will concentrate on developing sources of support to place several existing student activities on a firm footing, particularly those involving high school student research at BNL. These will be consolidated with other activities and events to build an ensemble of programs that can be tailored to meet the needs of a particular school district(s). We will place additional emphasis on developing learning activities featuring topics of high current interest at BNL, such as RHIC, or an onsite Environmental Science Trail, an experimental facility partly implemented by students, teachers, and parents from local schools. Our ability to support secondary teachers at the Laboratory can directly support such initiatives.

Once a robust BNL School District Technical Assistance Program is reestablished, we propose to convene a conference of key Long Island institutions and organizations interested in or actively engaged in supporting precollege MST education. The objective is to set up a system in which schools know what resources are available from the different organizations, and what is offered by different organizations.

A new initiative, Educational Technology Development is expected to receive increased DOE support over the next several years. We will respond with at least four major pilot programs, chosen for their ability to support program goals. Subsequent developments will reflect the outcome of these pilot efforts.

We will place increased emphasis on Program Integration. Through Educational Programs, the Laboratory has received recognition of its commitment to diversity, precollege and undergraduate technology education, pre-college science education, teacher enhancement and service to school districts. DOE has asked the Laboratory to take the lead in establishing a Department-wide educational initiative, and in organizing the scientific component of a program of student research intern presentations to Congressional staff and DOE program managers.

5.2 Other DOE Programs

Applied science and technology programs support the DOE missions in Energy Resources, Environmental Quality and National Security. Our intent is to expand our contribution by leveraging the Laboratory's unique assets in physics, life science, basic energy sciences, instrumentation, and user facilities. We have a comprehensive set of science and technology resources, underpinned by computational and information technology capabilities to achieve our goal.

In Energy Resources, a strong materials and chemical sciences program, combined with capabilities in biotechnology and nuclear science and technology, are the basis for new energy technologies that are environmentally acceptable and cost-effective for stationary power and transportation. The response to the combined needs of utility deregulation and carbon management will require small power systems amenable to either distributed power or high-performance transportation. BNL's traditional strengths in fuel cells, batteries, geothermal heat pumps, natural gas, and clean oil technologies position us well to contribute in this arena. Our nuclear capabilities will be channeled through the Nuclear Energy Research Initiative (NERI) toward a next-generation of small, benign, nuclear power-generation options.

National Security is increasingly global security; weapons of mass destruction can be transported in small quantities and delivered via low technology methods. The real global threat since the end of the cold war is war waged "out of a suitcase." The emphasis in the United States and developed nations for the future is containment, measurement, and mitigation of nuclear, chemical and biological weapons. BNL provides the perspective of a non-weapons laboratory. We will continue to apply science and technology derived from programs in basic biology, physics, materials, chemistry, and nuclear energy technology to issues of materials accountability and control, nonproliferation, weapons dismantlement, and the detection and mitigation of chemical and biological weapons.

While confronting today's issues of climate change, air pollution, and environmental cleanup, the Laboratory's long-term view for our programs in Environmental Quality is to focus on science and technology that supports sustainability. We plan the following three parallel tracks:

- Tropospheric aerosol chemistry to formulate practical and meaningful air quality standards.
- Monitoring and measurements of carbon to support sequestration options required in 2010 and beyond, and
- Biotechnology and other natural approaches to waste management and pollution prevention.

DOE programs would provide the pivotal base support, but investments are required from partnerships with other federal agencies (EPA, NOAA, USDA), state agencies (e.g., NYSERDA), and the private sector.

In each of these mission areas, our strategies have the following common themes:

- Build applied programs from the strong scientific base in materials, biology, chemistry, and physics,
- Use BNL's unique facilities and capabilities, such as NSLS, the Instrumentation Division, and FACE,
- Secure related work from other federal and state agencies, such as EPA, DOT, DOD, and NYSERDA,
- Collaborate with other national laboratories, universities, and private industry; and
- Put science and technology to work through a strong commercialization program integrated into the region's economic-development network of venture capital, incubators, and other business resources.

Several Offices within the DOE fund our applied science and technologies programs. Other federal, state and local agencies support related activities, most notably, the Nuclear Regulatory Commission (NRC), the Environmental Protection Agency (EPA), the Department of Transportation (DOT), and the Department of State (DOS).

Energy Efficiency and Renewable (EE http://www.eren.doe.gov/ee.html**):** The Thermal Distribution Systems in Small Buildings program explores heat loss in residences, while the Combustion Equipment Space Conditioning Technology program deals with improving residential heating systems. To date, over 0.83 quads of cumulative distillate oil savings have been realized as a result of such work. Through the Krakow Clean Fossil Fuels, we assisted the City of Krakow, Poland, in reducing emissions and improving air quality. We continue to address the following:

- Degradation in efficiency associated with a fuel's composition and combustion characteristics,
- The lack of control options for monitoring the system performance;
- Mechanisms for safely venting combustion products from very high-efficiency systems, and
- The lack of technology-transfer mechanisms within the industry.

In the Natural Gas Storage Systems program we assess the production of Liquid Natural Gas (LNG) from landfills, remote well sites, pipeline gas, and coal mines. Other aspects of the program involve developing state-of-the-art storage tanks and refueling facilities, designing novel cryogenic fuel delivery systems, and evolving strategies for market end-use. Our work in LNG fuel handling on vehicles includes such topics as design of fuel tanks, development of a vaporizer, and studies of high-pressure fuel delivery, and engine specifications.

We also focus on minimizing the potential adverse environmental, health, and safety impacts associated with the production, delivery, and use of photovoltaic energy in the DOE Photovoltaic Program. In FY2000, we will emphasize DOE’s Million-Roof Program.

Brookhaven's expertise in the physiology of natural microbes includes those that can act as biocatalysts for geothermal brines. Research in Advanced Biochemical Processes for Geothermal Brines has lead to processes for treating brines whose chemical content causes them to be classified as toxic or regulated wastes. We identified biocatalysts that can convert insoluble species of toxic metals, including radionuclides, into soluble forms. In furthering the use of geothermal power, we synthesized high-temperature, corrosion-resistant, chemically inert cements and grouts that are in our Geothermal Materials Development program. This program is closely coordinated with private-sector investments in geothermal wells.

Our work in developing geothermal energy is expected to continue and will be closely coordinated with private sector investments. Similarly, work on fuels and buildings will continue to improve the efficiency and reduce their environmental impacts, as part of DOE's carbon-management objectives.

Fossil Energy (FE http://www.fe.doe.gov/**):** Our core capability in microbiology is focused on ways to enhance oil recovery and reduce the sulfur, nitrogen, and trace metal content of crude oils. We demonstrated the technical feasibility of microbial-enhanced recovery with different types of biocatalysts under various processing conditions and with different heavy crudes. The economics of the process are promising. A joint DOE-industry program through the DOE Office of Economic Development and Technology Transfer was established with a start-up company, BioCat, to commercialize the process by constructing a pilot plant and transferring the technology to oil producers.

BNL staff analyze the environmental, health, and safety issues associated with the release of hazardous pollutants from coal-fired power plants, and air-quality standards for particulate matter. We are investigating a way to synthesize methanol through methane decomposition with reduced emissions of carbon dioxide and toxic gases as a viable alternative for producing methanol.

We will continue to pursue funding to use our expertise in microbial genetics and biochemistry to advance our understanding of the molecular bases for desirable microbial actions. In response to carbon sequestration, we are developing a new program in methane gas hydrates that combines biological and low-temperature catalytic processes.

Nonproliferation and National Security: (NN http://www.nn.doe.gov/default.htm**)** Our emphasis is on the safeguarding of Russian special nuclear materials, providing technologies to the United States and to international organizations to support treaty verification and to prevent, detect, and respond to events associated with weapons of mass destruction. Our focus is on the following:

- To secure the nuclear material in the former Soviet Union,
- To establish transparent and irreversible nuclear reduction,
- To strengthen the nuclear nonproliferation regime,
- To assure safe storage and disposition of surplus fissile material, and
- To help develop non-military applications for defense technologies and personnel.

BNL has over 40 projects to stabilize Russian scientific and technical personnel and resources that represent a proliferation risk. Staff also are developing hardware and systems for treaty verification and for ensuring nuclear, chemical, and biological nonproliferation

We provide technical support to other international safeguards programs in the following areas:

- Fissile material production cutoff ,
- US/IAEA agreements, the U.S. excess nuclear materials offer, and the IAEA Strengthened Safeguards System ,
- Highly Enriched Uranium purchase transparency,
- START-III transparency,
- Verification systems for nuclear weapons dismantlement (CIVET) for START-III and the Mayak Storage facility, and
- The US/Russia Plutonium Production Reactor Agreement.

BNL is developing radiation measurement systems as domestic safeguards against nuclear materials and for verifying the nuclear components in weapons returned to the DOE complex.

Under the Counter-Terrorism and Critical Infrastructure Program (energy, communications, and transportation), BNL is exploring technologies and providing technical support to US government agencies. The ability to detect explosive, chemical, biological, and improvised nuclear weapons is a key factor in countering acts of terrorism and protecting US critical infrastructures. The detection systems will give early warnings and deter terrorist attacks.

BNL's staff assist DOE in planning the US support for the Russian Nuclear Submarine Dismantlement. We develop and prepare technical analyses focused on the threats to proliferation and environmental security presented by Russian Naval spent fuel.

The DOE's Office of International Nuclear Safety is engaged in a comprehensive cooperative effort to reduce the risks at Soviet-designed nuclear power plants. With various host countries, the United States leads efforts to correct major safety deficiencies and establish safe, self-sustaining infrastructures. BNL staff, under the programmatic leadership of PNNL, initiated more than 150 projects at nuclear installations, many of which had an immediate impact in reducing risk. Our focus is on training, simulator development, safety-system upgrades, fire-hazard analysis, and technology transfer.

The DOE program, Initiatives for Proliferation Prevention, plans to employ weapons scientists of the Former Soviet Union in non-weapons-related research and commerce. BNL has over fifty individual projects, which reflect the overall research portfolio of the Laboratory: accelerator technology, biology, medicine, and nuclear technology. Three cooperative research

and development agreements with private industry are funded under this program, and we expect this effort to expand.

The Long-Term Viability Program is a new program begun in FY99. BNL's scientists, with scientists from other national laboratories, are assisting in designing and installing protection, control, and accounting systems (MPC&A) at sites in Russia, the Newly Independent States, and Baltic states to protect nuclear materials from insider and outsider threats.

Opportunities in global security are growing for BNL. Our special capabilities include novel detection devices, software, risk analyses, and training. We will continue our partnership with scientists in key institutes in the Newly Independent States of the Former Soviet Union, under the Initiatives for Proliferation Prevention (IPP) program to:

- Explore technologies suitable for commercialization,
- Stabilize the technology base, and
- Prevent and reduce proliferation of weapons of mass destruction.

We will continue work on detecting and preventing attacks from chemical and biological weapons, investigating pathogenic genomic indicators for detection and speciation, and characterizing the structure and function of biological toxins. This work is a direct response to recent Presidential and Congressional initiatives on US Domestic Preparedness against Chemical and Biological Terrorism.

We also expect growth in our work on dismantlement of Russian submarines in support of the US involvement in START as well as the new Threat Reduction Initiative. In the International Nuclear safety program, our work on developing simulators will continue, but at a reduced level.

We expect continued growth in the area of non-proliferation, detection, mitigation and response to nuclear, biological, and chemical weapons. We will, where appropriate, assume overall project management and coordination and create teams including other national laboratories, universities, and the private sector.

Nuclear Energy (NE http://www.NE.doe.gov/**):** BNL will continue to support the Office of Nuclear Energy Science and Technology in the US program to enhance the safety of Soviet-design power reactors.

Two elements of the DOE's approach to nuclear R&D are aligned with our expertise, the Nuclear Energy Research Initiative (NERI), and the Nuclear Energy Plant Optimization (NEPO). BNL proposed ten wide-ranging initiatives under NERI, including the following two:

- An interactive design tool for assessing the effects of advance automation on personal performance and plant safety, and
- A novel non-proliferation concept that employs Th and U-235 fuel in a light-water reactor to eliminate the potential for producing Plutonium.

We will begin work for NEPO in FY 2000 on aging management, performance of high-burn-up fuel, reliability improvement, human performance with digital systems, determination of an operational strategy consistent with life extension and advanced designs, and the development of advanced operator interfaces.

Defense Programs (DP http://www.dp.doe.gov/public/default.htm**):** The DOE's Office of Defense Programs (DP) provides an infrastructure and intellectual capability to maintain the nuclear weapons stockpile, including replacing limited-life components and assuring an adequate supply of tritium for hydro-nuclear weapons. We provide technical support to the Accelerator Production of Tritium (APT) Program Office, based at Los Alamos National Laboratory that includes APT systems engineering, safety, materials characterization and evaluation, and target and blanket design and engineering. We also support work related to safety functions and responsibilities at DP facilities and verification of integrated management systems.

Through funding from the DOE Defense Programs Office, we supported the Accelerator Production of Tritium Office at Los Alamos National Laboratory. However, an alternative involving the light-water reactor was selected early in 1999, and our future involvement as a backup technology is uncertain.

Environment, Safety, and Health (EH) and Environmental Management (EM http://www.eh.doe.gov/portal/ and http://www.em.doe.gov/**):** The DOE's Office of Environment, Safety and Health (EH) has a comprehensive management organization, and personnel program to improve the safety performance of individuals, human systems, and their interactions with technical systems. BNL is involved in several areas such as reviewing site-wide and programmatic Environmental Impact Statements, analyzing operating experience at DOE facilities, supporting Secretarial Environmental Safety and Heath Initiatives and complex-wide vulnerability assessments. Staff assist in developing and applying nuclear-facility safety rules and guides for implementing and verifying Integrated Safety Management Systems, and in addressing specific safety issues such as backfits, seismic vulnerability, and accelerator-driven systems. We completed our work with DOE-EH in the radiological assistance program for the Marshall Islands, and we are assessing our future role in ultra-sensitive measurements of radionuclides for DOE and other potential customers.

The DOE-EM Mixed Waste Focus Area, Subsurface Contaminants Focus Area, and Decontamination and Decommissioning Focus Area fund work at BNL that involves developing, testing, and demonstrating innovative technologies to treat DOE wastes and cleanup contaminated sites throughout the DOE complex.

BNL assists EM in responding to the Russian Submarine Spent Fuel problem by helping the Russian Navy upgrade their radiation-protection programs. We provide training opportunities and facilitate the transfer of excess radiation-protection equipment. These efforts are coordinated with the Department of Defense's Arctic Military Environmental Cooperation Program. BNL also supports a program to help other countries decommission and dismantle former nuclear test reactors constructed under the Atoms for Peace Program.

Through a new program, BNL will demonstrate an innovative technology, in situ gamma spectroscopy, and statistical approaches to characterize radiation risks during the Decommissioning of the BNL Brookhaven Graphite Research Reactor.

We expect continued support from EH for technical assistance in safety review and standards development, but there was a downturn in support from EM for our waste technology programs. Therefore, we will focus on multiple sponsors. We will continue to work with BSA's two prime subcontractors, Bechtel and Waste Management Federal Services, to support cleanup at the Brookhaven site. We plan to build links with other DOE sites, specifically, Savannah River, Rocky Flats, and Hanford, to use our technologies and expertise for site-specific cleanup. We will continue to offer novel solutions to complex waste problems and work with our industrial partners to develop practical commercial products and services.

Policy Office (PO http://www.osti.gov/policy/home.html**):** We will continue to assist the DOE's Policy Office through systems modeling of global climate change, integrating the findings with the MARKAL-MACRO energy system model developed at BNL. We also will participate in the Energy Technology Systems Analysis Program (ETSAP) of the International Atomic Energy Agency.

5.3 Major DOE Partnerships

Relativistic Heavy Ion Collider (RHIC): RHIC, designed to create and explore a new state of matter, the "quark-gluon plasma" and to be world's highest energy source of polarized proton-proton collisions, represents a major collaborative effort among the US DOE Laboratories, US universities, and worldwide scientific communities. The four RHIC detectors, BRAHMS, PHENIX, PHOBOS, and STAR, involve more that 850 scientist from five DOE National Laboratories, 40 US universities, and 50 non-US institutions from 19 different countries. Each of the collaborating DOE Labs, as well as many of the US universities and foreign institutions contributed to the design and construction of the detectors and will participate in the experimental program beginning in 2000.

Large Hadron Collider (LHC http://www.hep.net/doe-hep/lhc.html**):** Brookhaven plays an important role for United States in the LHC Project and the subsequent scientific program. BNL is the host laboratory for US participation in the ATLAS detector. We also manage the US contributions to this detector, positioning US scientists for effective collaboration in the physics research program. BNL collaborates with two other DOE laboratories (ANL and LBNL) and with research teams from about 29 universities in the United States. BNL is also a member of a three-laboratory team (with Fermilab and LBNL) that manages the US contributions to the accelerator part of the LHC Project. BNL will test all the LHC superconducting cable and produce a set of RHIC-type superconducting magnets for the LHC machine lattice. We also contribute important expertise to the LHC accelerator physics effort.

Muon Collider (http://www.cap.bnl.gov/mumu/mu_home_page.html**):** Three potential technologies are possible successors to the LHC linear electron-positron colliders, muon colliders, and very large hadron colliders. The world's high-energy physics community will vigorously pursue R&D to refine the technical merits of these technologies and to characterize

their costs and scientific applicability to the next generation of research in particle and nuclear physics. A BNL spokesperson is a key member of a multi-institution Muon Collider Collaboration, initiated in 1997. The goals of this collaborative effort are to explore the feasibility of a practical multi-TeV collider and to undertake computer calculations and experimental tests of muon collider concepts. We are consolidating the group's efforts in a more directed program of exploratory R&D, employing a project management approach. Members of the collaboration include 9 national laboratories and 17 research university groups. An early version of a muon collider with neutrino beam capabilities is proposed as a new BNL Initiative.

Spallation Neutron Source (http://www.ornl.gov/sns/**):** The spallation Neutron Source is a 1 GeV, 2 MW proton facility that will be built at the Oak Ridge National Laboratory. BNL is a member of a 5 Laboratory consortium (Argonne National Laboratory, Los Alamos National Laboratory, Lawrence Berkley National Laboratory, Oak Ridge National Laboratory, and Brookhaven National Laboratory) that will construct the world's most powerful accelerator-based neutron source for the DOE Basic Energy Sciences program. BNL's responsibility is the design, construction, and commissioning of the 1 GeV accumulator ring and the beam transports from the linac to the ring and from the ring to the target station.

D0 Collaboration (http://www-D0.fnal.gov/**):** BNL helped design and build Fermi Laboratory's D0 detector and for many years has been part of a key user-group at D0. This very productive research effort continues. The recent announcement of the discovery of the top quark by the D0 Collaboration is evidence of this productivity; BNL's physicists played a leading role in that successful search. Now BNL is providing new apparatus to upgrade D0. When the improvements are complete, BNL will be a leading participant in a multi-year experimental search for the Higgs boson, and for physics beyond the Standard Model.

Other Collaborations in High Energy and Nuclear Physics: BNL's nuclear physicists are involved in several upcoming experiments at the Thomas Jefferson National Accelerator Facility (TJNAF) and will continue to be for several years. BNL's nuclear chemists have contributed significantly to solar-neutrino experiments and will continue for the foreseeable future. The successful GALLEX Collaboration recently concluded it program with exciting results on the solar-neutrino puzzle, and BNL researchers now are turning their attention to the Solar Neutrino Observatory in Canada where the United States has significant involvement through the DOE Nuclear Physics Division.

Global Climate Change and Carbon Management : BNL participates in the multi-laboratory and university collaborations on global climate change and carbon management proto-cols. BNL leads the FACE program and has a principal role in the ARM program. We are working closely with Pacific Northwest National Laboratory and Oak Ridge National Laboratory to integrate the various tasks in DOE's climate change response, and to link with the other agency participants from National Oceanographic and Atmospheric Agency, and National Space and Aeronautics Agency. National coordination and integration is essential for developing a unified climate change model as proposed as part of the Strategic Simulation Initiative.

International Nuclear Safety Program: BNL is a member of the national laboratory team headed by Pacific Northwest National Laboratory to ensure the continued safety and

orderly shutdown of the Former Soviet State's reactors. The team corrects major safety deficiencies and establishes nuclear safety infrastructures that will be self-sustaining. More than 150 joint projects were initiated at nuclear installations. BNL's focus will continue to be in the areas of training, simulator development, safety system upgrades, fire hazard analysis, and technology transfer.

Initiatives for Proliferation Prevention: BNL is an active participant with the other multi-program laboratories and the Kansas City Plant in the Initiatives for Proliferation Prevention Program. This program develops partnerships with scientists in key institutes in the Newly Independent States of the Former Soviet Union to develop technologies appropriate for commercialization. The program seeks to employ former weapons scientists of the Former Soviet Union in non-weapons related research and commercial activities. BNL has initiated over fifty individual projects that reflect the overall research portfolio of the laboratory. We will expand our existing program by developing additional cooperative research and development agreements with US industry. We will make use of our interactions with LISTNET to engage local software development companies in this program. We will participate in the Nuclear Cities Initiative, which seeks to provide commercial opportunities for the former weapons scientists in the ten closed cities of the Russian Federation.

5.4 Work For Others

Federal Sponsors: Several of our biomedical centers and facilities have developed or operate through partnerships with, and funding support from, other federal agencies or other funding sources. These Centers include our Imaging and Neuroscience Center, the Scanning Transmission Electron Microscope and the Structural Biology Programs at the NSLS. This type of partnership and distributed support is important in advancing science and technology in the national interest.

NIH provides substantial support for biomedical research through grants to individual investigators. Such grants support work at the Imaging and Neuroscience Center, investigations on DNA damage and repair, protein structure and folding, viral proteases and receptors, and the Lyme disease bacterium. With support from NIH, we will collaborate with the Medical Center at the University at Stony Brook for genomic, biochemical, and protein structural analysis of the Lyme disease bacterium and emerging pathogens of regional interest.

The construction and operation of the Booster Applications Facility for NASA (http://bnlstb.bio.bnl.gov/) represents DOE's close government partnership to provide extraordinary facilities and capabilities for research on issues of national concern. This initiative is consistent with BNL's Critical Outcome to provide innovative science and our strategic objective to apply our unique research facilities to issues of human health.

The October 1997 Implementing Arrangement established a collaboration between NASA and the DOE. The major goals of the collaboration are the following:

- To use BNL's unique accelerator facilities, such as the Alternating Gradient Synchrotron (AGS) and the Booster, to simulate aspects of the space radiation environment,

- To support investigations of the response of living systems to radiation exposure in space, and
- To promote developments in science and technology that meet NASA's requirements for radiation protection in space.

The Booster Applications Facility will deliver a complete range of high-atomic number, high-energy heavy ion beams with energies from 40 MeV/A to 1500 MeV/A, depending on the particular ion species. The first substantial funding was received in FY 1999 to start constructing the facility. The major emphasis during FY 1999 was directed to completing Title 1 civil construction and initiating Title 2, as well to engineer the beam equipment and the expedite the Tandem upgrade.

Brookhaven's capabilities and skills also extend to international work supporting DOE and its sister agencies in transferring technology to friendly nations. Our near-term focus is the former States of the Soviet Union, specifically reactor safety, and decommissioning the nuclear navy. BNL supports the EPA's Office of International Affairs and DOD in several environmental cleanup projects in Kazakstan. Brookhaven's International Safeguards Project Office (ISPO) assists the International Atomic Energy Agency (IAEA) in nuclear safeguards. Our MARKAL-MACRO computer code is being used increasingly by developing nations to help them design energy-efficient infrastructures.

BNL designated growth in our science and technology work for other federal agencies as a goal over the next three to five years. We will accomplish this goal by increased interdisciplinary research collaborations that will expand our ability to address issues of environmental quality, national energy needs, global security, and human health.

We will continue to seek partnerships with the Division of Research Resources and the National Institute of General Medical Sciences (NIGMS) of the NIH to develop facilities for medical research at the NSLS and increase their usefulness to the wider research community. The NIH Division of Research Resources has funded work at BNL to support technology development and to increase users' access to a cluster of five protein-crystallography beamlines. The NIGMS also is exploring ways in which their support can increase the efficiency and users' access to protein-crystallography beamlines at the NSLS. We will apply the information gained to develop better diagnostics, vaccines, and therapeutics. We plan to search for single-nucleotide polymorphisms in human genes that are important for recognizing and repairing DNA damage, starting with the DNA-dependent protein kinase and related genes.

We will seek increasing support from NASA, NIH, EPA, DOD, and DOT offering our unique user facilities and expertise. For the DOD, we will expand our work on chemical and biological defenses. For NIH, we expect increasing use of our cancer diagnostic and treatment facilities and expertise. For EPA, the Corps of Engineers and the Navy, we are proposing to expand our harbor sediments program in conjunction with the University at Stony Brook and Battelle-Duxbury. We intend to use our expertise in human factors and risk assessment, combustion and cable test facilities, and the Raman LIDAR system for the Department of Transportation, to address aircraft safety and airport security.

While the Nuclear Regulatory Commission (NRC) budget sharply decreased over the past three years, and support for BNL decreased accordingly, we expect funding to continue in certain areas. However, in other industries, as well as in the international nuclear-power community, we see potential growth in the use of our technologies, and we intend to exploit this growth area while maintaining our current multi-year programs with the NRC. We also will pursue non-nuclear markets that need the capabilities of our two test facilities, the Combustion Test Facility and the Electric Cable Test Facility (e.g., the chemical and aerospace industries).

Non-Federal Sponsors: Historically, sponsored research has been an underused component of the Laboratory's Technology Transfer Program; now it is recognized as an opportunity for future growth. BNL will strenuously seek to expand its sponsored research with non-federal entities in areas that are relevant to DOE's research missions. BNL has many unique capabilities and facilities not available in the private sector that offer opportunities for sponsored research in environmental sciences, energy technologies, transportation research, and biotechnology.

BNL's atmospheric chemistry and oceanography programs are extensively involved in sponsored research programs; several leverage DOE's investments in atmospheric chemistry. BNL's work for North Carolina State University involves data analyses with a series of diagnostic modeling exercises to understand the photochemical process forming ozone in the Nashville area. We conduct similar research for the Pennsylvania State University by investigating the relationship among conditions leading to high ozone concentrations and increased levels of particulates in the urban polluted environment. Laboratory staff participate in a program sponsored by Science Engineering Associates (SEA) to develop a unique application for a tracer technology developed by BNL for atmospheric studies; this tracer technology reveals leaks in underground containment barriers.

Our oceanography capabilities are the basis for a number of active sponsored research programs. Through the Woods Hole Oceanographic Institution (WHOI), BNL participates in the Global Ocean Ecosystem Dynamics (GLOBEC) program. We have placed moorings and collected data for GLOBEC to establish a fundamental understanding of how the abundance of key marine animal populations varies in space and time. On a local level, we participate in a program sponsored by Suffolk County, using instrumentation developed at BNL to study the relationship between dissolved organic nitrogen and the brown tide blooms in the Peconic Estuary and the Great South Bay. Brown tide has significant environmental and economic consequences on Long Island.

BNL participates in the Long Island R&D Initiative, sponsored by the local utility, KeySpan Energy, to develop new technologies with potential application in the utility industry. Staff use their experience with high-performance polymer cements to recycle boiler ash and other power-plant waste products. Waste materials incorporated into a composite cement are used for rapid-setting patch materials to repair damaged roadways. In another project, the efficacy of a BNL-patented soil-remediation process is being tested in a feasibility study at KeySpan sites that have been contaminated by lead paint.

BNL participates in the Transportation Infrastructure Research Consortium (TIRC), funded by the New York State Department of Transportation (NYSDOT). We are developing new software that will assist the NYSDOT in implementing passive snow-control measures to reduce winter maintenance costs and improve highway safety. We are producing an expanded tort database and risk methodology for NYSDOT that is expected to mitigate traffic accidents and the State's associated tort liabilities. We are applying our capabilities in human factors engineering (HFE) in a program sponsored by the American Bureau of Shipping to develop HFE guidance for designing and evaluating complex human-machine systems in merchant vessels.

Our biomedical research programs and capabilities are of value to several sponsors. We are conducting a study for KGL, Inc. to assess the DNA-damaging effects of agents applied topically to human skin. Several such agents, with cosmetic or medical uses, seem to increase sensitivity to ultraviolet-induced sunburn. BNL's research in Positron Emission Tomography (PET) continues to contribute in several studies with New York University Medical Center. PET studies have been extremely effective in monitoring the brain's metabolic functions and providing new insight into treatments for schizophrenia, Alzheimer's disease, and various addictive behaviors.

5.5 Technology Transfer

The Science and Technology Program has four goals, the last of which is to "Add value to the US economy through the development and application of new and improved technologies."

BNL's technology transfer program has two primary objectives (http://www.bnl.gov/techxfer/tech_transfer.html). First, through involvement of BNL in technology transfer projects we will complement our research mission and enhance our capabilities to undertake research on behalf of DOE. Second, the technology transfer program will allow technologies and technical capabilities developed at BNL to become resources for US industry, enhancing competitiveness in domestic and international markets. BNL uses the following mechanisms for technology transfer:

- Use by industry of Brookhaven's world-class designated user facilities,
- Sponsored research,
- Cost-shared research projects under Cooperative Research and Development Agreements (CRADAs), and
- Intellectual property licensing.

The Laboratory's Office of Economic Development and Technology Transfer is responsible for BNL's patent prosecution and licensing program, the research partnership program with industry CRADAs, the sponsored research program with industry, universities, and state and local governments, the facility agreements for designated user facilities, the Laboratory's technical assistance program for industry, and the personnel exchange and technology maturation activities.

Brookhaven National Laboratory

Brookhaven Science Associates has the right to take title to the technologies invented by Brookhaven employees at the Laboratory and the patents covering them. The following are examples of promising technologies that are available for licensing;

- Biological materials and processes, including gene expression systems, DNA-sequencing processes, and recombinant plasmids for encoding restriction enzymes,
- Metal primers and coating compositions,
- Environmental remediation techniques, including microbial materials that remove toxic metals from contaminated wastes,
- Radiolabeled monoclonal antibodies for diagnostics and therapeutics, and
- Instrumentation for preparing radiotracers for medical research and clinical applications.

Inventions arising from our biotechnology research programs continue to be of special interest to industry. Our strengths in medical imaging, radiopharmaceuticals, nuclear medicine, molecular genetics, genomics, structural biology, and protein engineering continue to produce new technology that is licensed to industry. Technology based on our T-7 gene expression system continues to evolve, with new patents issued and new commercial licenses continuing to be granted. Currently, there are 109 technologies in BSA's Patent Licensing Portfolio; 42% of these technologies are licensed to industry, and 23% of the licensed technologies been commercialized, with new products based on these technologies now on the market. The net revenue generated by the licensing program, which is re-invested in the Laboratory's research programs, continues to increase each year. At the same time, the licensing program continues to be very cost effective, with the costs of patent prosecution, patent maintenance, and licensing being 28% of the gross revenue in FY 98 and 23% in FY 99. (Licensing Information is provided in Appendix C).

Over the past several years, CRADAs have proven to be a valuable component of BNL's research portfolio. CRADA research programs enhance BNL's research capabilities and advance DOE's scientific missions by providing access to industrial expertise and capabilities. These cost-shared programs have generated several new technologies and numerous patents, have created new commercial products and processes, and have demonstrated the societal relevance and public benefit of DOE research.

BNL's participation in CRADAs (Appendix A) is primarily funded by the following three sources:

- DOE's Office of Science-Laboratory Technology Research (LTR) supports most of BNL's programs,
- Increasing support comes from the DOE Industrial Partnering Program for the Newly Independent States (IPP-NIS) of the former Soviet Union.
- Industrial partners give their support in jointly developing a BNL-patented technology for commercialization.

Brookhaven National Laboratory

The DOE Laboratory Technology Research program supports high-risk, multidisciplinary research partnerships to investigate challenging scientific problems of interest to the DOE, whose solutions have promising commercial potential. BNL's participation in this enterprise relies on several strengths including research on electronics/instrumentation, energy, the environment, and biotechnology.

The instrumentation capabilities at BNL are used in three active CRADAs funded by LTR. We are working with a local Long Island company, Symbol Technologies, to design, fabricate, and test two novel devices for collecting and transmitting data, an optical photosensor array, and a 2.4 GHz, single chip, frequency agile radio transceiver. Symbol Technologies expects this developmental program will result in new wireless capabilities for scanners, data terminals, and local area networks. BNL's CRADA with II-VI, Inc. is to develop Application Specific Integrated Circuits (ASIC) for the pre-amplification and processing of signals from Cadmium Zinc Telluride detectors. This CRADA relies on the material science expertise of II-VI and BNL's experience in low-noise custom electronics. The third project with a small Long Island business, Brookhaven Technology Group, is to generate a compact, cost-effective, high-brightness 5 MeV electron gun. Such high-brightness electron beams are needed for high-luminosity electron colliders and efficient short-wavelength Free Electron Lasers.

BNL's long history in developing new energy-related technologies is essential to two other DOE-LTR-supported CRADAs. The Laboratory participates in a cooperative research program with Oxford Superconducting fabricating new superconducting materials. BNL will contribute significantly to the understanding of the interface structures between the superconducting materials, the buffer layers, and the substrates by employing transmission electron microscopy. This understanding is essential for selecting materials and establishing deposition processes in the manufacture of superconducting wire. BNL also plays an important role in developing advanced batteries. BNL and Gould Electronics are jointly exploring new electrode and cathode materials for rechargeable lithium batteries. The Laboratory established new methods of characterizing in-situ x-ray absorption and X-ray diffraction spectroscopy that are being used to study the relationship between performance and structural characteristics of new battery materials.

LTR-funded CRADAs leverage DOE's investment in biotechnology research at BNL. BNL and Oncogene Research Products are engaged in cooperative research to develop reagents to detect specific responses to DNA damage; the work is expected to have an important impact on ongoing biomedical research in cell growth and cancer. Oncogene anticipates that this research will lead to techniques for testing the effectiveness of specific cancer therapies. BNL continues its joint research with Diatide to develop and test the application of tin-117m DTPA to treat bone cancer in humans. This CRADA will expand on a successful collaboration between BNL and Diatide that developed tin-117m to palliate pain in bone-cancer patients.

The DOE-LTR program has funded several promising environmental technologies over the years. At present, BNL is beginning a research program with PhytoWorks, Inc. to study the basic mechanisms by which plants take up contaminants from sediments contaminated with toxic metals and radionuclides, and ultimately, to explore methods which enhance this update of contaminants.

BNL continues its participation in the AMTEX initiative, which is partially supported by DOE-LTR. Our scientist conducts research with Cotton, Inc. to understand the basic relationships of structure and function in the cotton plant. We will identify the key genes that influence cotton-fiber traits, such as its length, strength, and thickness, and will seek to modify these genes so that Cotton, Inc. can produce transgenic cotton plants and evaluate the properties of the fiber.

The Industrial Partnering Program for the Newly Independent States (IPP-NIS) program supports research partnerships at BNL, which take advantage of the research capabilities of established scientific institutions in the NIS and the commercialization expertise of industry. DOE supports the research conducted by BNL and the NIS institute, while our industrial partner supports its own work through a CRADA. BNL is a participant in two IPP-NIS CRADAs and is aggressively pursuing additional opportunities. BNL and Radkowsky Thorium Power Corp. work with the Kurchatov Institute to develop a new type of fuel for nuclear reactors. We also cooperate with the General Physics Institute in Moscow and Aquila Technologies to develop better surveillance instrumentation and techniques that will be used as a measure of accountability under the Nuclear Non-Proliferation Treaty.

The Laboratory has successfully attracted Industry Supported Cooperative Research to develop BNL technologies. BNL is working with a small company, SCRAM Technologies, to develop the BNL-patented polyplanar optic display (POD) as a commercial flat panel display, and with Consolidated Edison on a project to adapt BNL's tracer technology to locate leaks in underground power lines. We are also cooperating with the New York State Energy Research and Development Authority to advance the commercialization of a novel oil-fired heating system developed at BNL.

BNL identified technology transfer as a potential growth area in the Laboratory's overall R&D portfolio. We will vigorously pursue initiatives to expand research partnerships to support the Laboratory's overall strategic plan and to build on recognized research capabilities and our unique scientific facilities.

The Laboratory's work for non-federal sponsors allows us to carry out research for industry, universities, non-profit sponsors, and state and local government. This program is of great significance for technology transfer. We anticipate more interactions with the medical-products-and-health community, New York State utilities, the environmental industry, and the electronics industry in our region as a result of our growing relationship with SUNY's Centers for Advanced Technology (Stony Brook biotech and sensors, Albany fuel cells), New York State's Energy Research and Development Agency (NYSERDA), and the Long Island Forum for Technology (LIFT).

The Laboratory will continue expanding the Intellectual Property Licensing Program to effectively foster the marketing of our new technologies. We will seek private investments to accelerate the development of technology to the commercial stage through a contractor-funded program and incentives to encourage staff to commercialize their technologies (e.g., Entrepreneurial Leave). We will explore the possibilities that computer software, originated at

BNL, may have market applications and be appropriate for copyrighting and licensing.

6.0 Initiatives

Brookhaven National Laboratory presents initiatives in two categories. The first are Laboratory Initiatives that articulate our future vision for BNL and assure our overall long-term mission viability. Laboratory Initiatives respond directly to DOE's Science and Technology mission, pushing the frontiers of science forward in areas of vital national interest. They will receive the focused attention of the Laboratory Director and the Integration Council, and the support necessary to convince the DOE that BNL is the right place to invest its future resources. A significant fraction of our Laboratory Directed Research and Development (LDRD) funds are or will be applied to these initiatives.

The second category, Programmatic Initiatives, builds on and extends our research and technology-base. These initiatives respond to developments within BNL and new opportunities presented by DOE, other federal agencies, New York State, and industry. They enhance our role in DOE's missions and add value to DOE's R&D portfolio. These initiatives will receive the focused attention of the cognizant Associate Laboratory Directors who are responsible for assembling the interdisciplinary teams and resources to respond to requests for proposals and other program solicitations. The Programmatic Initiatives will be in competition for available funds.

Initiatives are provided for consideration by the Department of Energy. Their inclusion in this plan does not imply the DOE's approval of or intent to implement an initiative.

6.1 Laboratory Initiatives - Science and Technology Mission

6.1.1 Deep Ultraviolet Free Electron Laser Research Facility (Extraordinary Tools)

(http://www.nsls.bnl.gov/BeamRD/Erik/SDL.html)

BNL developed an R&D capability to study free electron laser concepts in the deep ultraviolet (DUV-FEL) to continue the Laboratory's mission to provide extraordinary tools for advancing science and technology. While we continue to improve the NSLS storage rings to advance synchrotron-radiation research, it is clear that Free Electron Laser (FEL) based sources can provide research opportunities unavailable with any alternative technology. Linac-based FELs promise twelve orders-of-magnitude improvement in peak power over storage rings, and access to phenomena at subpicosecond time-scales. Laboratory scientists have made significant theoretical and experimental contributions to FEL R&D. DOE/BES supported a limited use of R&D funds in this area, and funded a multi-laboratory/university experiment at the Accelerator Test Facility (ATF) to test self-amplified spontaneous emission (SASE) in the visible region (VISA experiment). The BESAC panel on synchrotron sources recommended an R&D effort for developing FELs operating in the hard X-ray region. A second panel (Leone Committee) recommended a national R&D program related to an X-ray FEL and emphasized that these future light sources would result from a marriage of laser- and accelerator-technology. BNL is involved in both of these areas. First, BNL is a collaborator in the Linear Coherent Light Source (LCLS) project at SLAC that will lead to a demonstration of SASE in the hard x-ray region. BNL is doing R&D on high brightness laser cathode electron guns at the ATF and on electron bunch compression and coherent synchrotron radiation at the DUV-FEL. BNL also is

responsible for the development of fast electron beam diagnostics and is contributing to the scientific case for an X-ray FEL. Secondly, BNL is studying the marriage of laser- and accelerator- technology. BNL developed the concept of High Gain Harmonic Generation (HGHG) and successfully demonstrated the concept in the infrared at the ATF in FY99 (http://www.bnl.gov/bnlweb/hghg.html). Continuing R&D will lead to demonstrating HGHG in the ultraviolet at the DUV-FEL in FY01. This seeded beam approach to FEL design ensures that the stability in the wavelength, bandwidth, and pulse-length of the incident seed laser is imposed on the FEL output radiation. Unlike the SASE approach, HGHG leads to longitudinally coherent radiation whose time structure can be controlled by chirping the laser pulse. Theoretical studies at BNL suggest that the range of FEL operation can be extended to wavelengths below 10nm.

In the out years the DUV-FEL will be upgraded to produce sub-picosecond pulses of UV radiation at wavelengths as short as 50 nm and peak power of several hundred megawatts. It will be operated in a chirped-pulse mode producing four femtosecond pulses at 88nm with peak power of 100GW. This remarkable source will enable demonstration science experiments that will establish the capabilities of FELs and help to make the case for an eventual large FEL user facility producing radiation with wavelengths between the 100nm and hopefully 0.1nm. The research opportunities include quantum control of reaction pathways, non-linear optic studies of inner-shell processes and atomic stabilization.

This R&D program in FEL development, if successful, will establish the expertise and experience in FELs so that BNL will be an attractive site for the construction of an FEL user facility in the FY2005 time frame.

This union is the key element of the High Gain Harmonic Generation FEL concept proposed by BNL, and a demonstration experiment of this concept is underway at the ATF. The DUV-FEL will address some of the key issues included in the report of the Leone Committee and provide a facility in which to demonstrate the unique science possible with FELs.

The project's scope and approach will meet the needs of a national program of R&D, and would lead to the construction of a dedicated "Fourth Generation Light Source" around the year 2005. The DUV-FEL will provide the technical case for developing the source and scientific applications for a true user facility. It will produce sub-picosecond pulses of UV radiation at wavelengths as short as 50 nm and peak power of several hundred megawatts. It will be operated in a chirped-pulse mode producing four femtosecond pulses at 88 nm with peak power of 100 GW. The research opportunities include photochemistry of molecules important in atmospheric chemistry, quantum control of reaction pathways, and non-linear optic studies of inner-shell processes and atomic stabilization. BNL has invested significant discretionary Laboratory resources to advance the project. The accelerator system is being assembled from existing components.

In a multi-institutional collaborative effort, BNL developed seeded-beam approaches to amplifier FEL design. The seeded-beam FEL approach ensures stability in the wavelength, bandwidth, and pulse-length of the incident seed laser is imposed on the FEL output radiation. The ultimate objective is to provide radiation with properties that make it amenable for use as an experimental source. The work done to date suggests that the range of FEL operation can be

extended to wavelengths below 10 nm.

The budget projections include funds to complete the assembly of existing components, to construct the apparatus to use the FEL radiation and to extend the building to house some experiments. Machine developments include enhancements of the amplifier wiggler, an energy upgrade of the linac, and the installation of a high-power high-repetition rate Radio Frequency (RF) driver for the linac. These accelerator elements are important parameters to explore to develop an adequate knowledge base for designing a dedicated "Fourth Generation" user facility.

Investigators from outside BNL will use the FEL while it is still under development. This close interaction between end-users and source-developers will focus research activities on the properties of the FEL that will be most important for future research.

6.1.2 Muon Collider and Storage Ring Neutrino Beam Study (Extraordinary Tools)

(http://www.cap.bnl.gov/mumu/mu_home_page.html)

BNL proposes to study the possible construction, at BNL, of a "First Muon Collider", with a center of mass energy of the order of 200 GeV. As a first stage, the intense muon source would be used to fill a muon storage ring with 50 GeV muons to produce neutrino beams. The initiative would include a general study of such neutrino sources from a muon storage ring.

A group at BNL is a major player in a DOE-funded, multi-laboratory/university collaboration studying the feasibility of muon colliders at generic sites. If their technical problems can be solved, these machines would be smaller and cheaper than the linear electron-positron colliders currently proposed (NLC by SLAC, JLC by Japan, and TESLA by DESY in Germany). Precision studies of high-energy particles in the 0.1-1 TeV energy range can be done with either an electron-positron or a muon machine. These studies would complement and extend those at the Large Hadron Collider being built in Switzerland. In addition, a muon collider offers unique capabilities not available with an electron-positron collider, such as precision resonance measurements of a Higgs Boson.

The Brookhaven proton accelerator, the AGS, is currently the most intense source of proton beams suitable for driving a muon collider. We will explore improvements to the AGS that would meet the full requirements for a muon collider, estimate the cost of such upgrades, and compare these with proposals from other Laboratories.

We also will investigate the possibility of a first phase muon collider facility that would generate a more powerful and better-defined neutrino beam than any currently available. The improved AGS would produce muons that are then accelerated to about 50 GeV and stored in an elongated storage ring. Decays occurring in the straight sections of the ring generate the neutrinos for the beam. The neutrino beam could be directed to a detector located many thousands of kilometers away and would allow studies of neutrino oscillations in channels (i.e. appearance experiments), and with precision not currently possible. Different source and detector locations would be compared. The source at BNL and detector at Soudan, Minnesota (1900 km), or in Gran Sasso, Italy (6700 km) are particularly interesting possibilities. Designs of the muon capture, limited cooling, acceleration and storage, needed for such a facility, would be explored, including the special geotechnical questions related to building the storage ring at an angle (9

degrees for BNL-Sudan, 31 degrees for BNL-Gran Sasso). We would consider the potential for the storage ring to be upgraded and used as an injector for the "First Muon Collider".

Finally, we will study the physics potential of the neutrino beam facility. Emerging experimental evidence suggests that neutrinos have small masses, and that they mix, one flavor into another. The determination of the Maiani matrix that describes the mixing will be a major challenge. A muon-storage-ring source for neutrinos offers great advantages for such studies.

- The neutrino energy can be high enough to allow mixing into all flavors.
- In addition to muon neutrinos the beam would contain large numbers of anti-electron neutrinos, present only as a small background in conventional beams.
- The beams would be far more mono-energetic than existing beams.
- The beams would be very well known and specified. Existing beams require extensive and uncertain Monte Carlo studies to determine their content.

6.1.3 Data Intensive Computing (Extraordinary Tools)

(http://www.cdic.bnl.gov/)

Recently, Brookhaven created a new Center for Data Intensive Computing (CDIC) under the directorship of an eminent computational scientist, to achieve the following:

- Establish a world-class research effort in computational science that addresses the needs of DOE programs.
- Provide the intellectual resources to deal with the long-term computing needs of the Laboratory.

At BNL those needs are principally related to very large data sets. A broad-based, intensive research effort in computational and computer science is needed to fulfill this role. This effort also contributes to the Department of Energy's Strategic Simulation Initiative (SSI http://www.er.doe.gov/production/bes/strat_plan.htm) and to its goals in applied mathematics and advanced computation. CDIC will be a leading facility in all aspects of managing data, storage, assimilation, interpretation, analysis, and integration into predictive scientific and engineering models. National plans for Information Technology in the early 21st Century call for computing at the level of 100 teraflops, and data storage in the petabytes. Requirements for storing experimental and observational data are higher and will reach hundreds of petabytes. To be useful, this data also must be processed, visualized, analyzed, and understood.

The primary emphases of the Center will be

- Data mining,
- Visualization and graphics,
- Parallel and distributed computing and networking, and
- Modeling and simulation.

The Center also will be linked closely with Brookhaven's Scientific Programs and contribute to their productivity. BNL's Relativistic Heavy Ion Collider and our participation in the ATLAS collaboration at CERN dictate that we address issues of very large data sets. As a result, research was funded on a new object-oriented analysis framework using state-of-the-art software. In addition, efforts are underway to use the computing power of the RIKEN/BNL special-purpose computer, which has achieved teraflop speeds in lattice-gauge calculations for a problem in photonics.

In biological and environmental research a major expansion in computational biology is needed to support the Human Proteome Initiative, and to investigate new techniques to automate the analysis of protein-crystallographic data obtained at the NSLS and other synchrotron sources. A project was started in medical imaging using parallelism to speed the analysis of data from patient trials of Boron Neutron Capture Therapy. The experience gained with this project is expected to lead to advances in Positron Emission Tomography (PET), and in Magnetic Resonance Imaging (MRI).

In Global Climate Change, a project was funded to develop an aerosol module for General Circulation Models. Aerosols are a major unknown factor in modeling climate, and Brookhaven's expertise in this area will allow a realistic accounting of aerosol physics and chemistry in predicting climate.

Our work for Basic Energy Science in quantum dynamics and rate process in combustion will contribute to the Strategic Simulation Initiative (SSI) effort in combustion. We proposed an approached to simulating and modeling combustion that includes the following:

- Fine Continuum Simulation Studies,
- Direct Numerical Simulation Modeling,
- Calculations of Rate Constants using Variational Transition State Theory,
- Application of Quantum Chemistry to Potential Energy Surfaces for Elementary Combustion Reactions, and,
- Mechanism Reduction.

We also will work to build partnerships with the other DOE laboratories pursuing hardware aspects of SSI. The 3-D stereo imaging facility developed at Brookhaven will be improved and expanded. Based on experience gained at Stony Brook an effort will be made to assemble a 100 G-flop computer using commodity processors. We also plan to experiment with cost-effective mass-storage technologies that may be useful for managing the RHIC data.

Several projects were supported in of these areas in FY 99, and this support will continue next year. The Center will have a permanent Head by the fall of 1999 and will build staff up to ten people over four years. The Center will be linked with the Computer Science Department and the Applied Mathematics and Statistics Department at the State University of New York at Stony Brook. The Center's Director and some staff will hold joint appointments. The two institutions will share post-doctoral researchers and students. Recruitment of ten additional faculty members at Stony Brook is expected over the same period, many will hold appointments at the Center.

Finally, we plan to partner with PNNL and ORNL to develop new techniques for accessing large data sets as part of the Next Generation Internet; this application will be in the Atmospheric Radiation Measurement program.

6.1.4 Human Proteome Project (Exploring Energy and Matter)

(http://proteome.bnl.gov/)

The entire set of proteins specified by the genome of an organism is referred to as its proteome. The known proteomes for free-living, single-celled organisms range from several hundred to more than 6,000 proteins. Proteomes of multi-celled organisms are considerably larger. The human proteome is estimated to have 60,000-100,000 proteins.

We need to obtain protein structures representative of the range of protein families found in nature to understand the functions of the human proteins and to develop the informatic- and computational-tools to apply this information to human proteins. The determination of protein structures starting from DNA sequences, structural genomics, is widely applicable to other DOE missions, including the Microbial Genome Project and the use of microbes, plants, or enzymes in bioremediation or industrial processes that increase the efficiency or quality of energy production.

The Human Proteome Project is a large-scale, multi-disciplinary, cooperative effort involving national laboratories, universities, and industry. BNL will serve as a center for producing proteins and determining structures. The environment of a national laboratory is conducive to this activity, and the NSLS is ideally suited for collecting the crystallographic data needed for structure determination. As steward of the national laboratories and synchrotron sources, DOE will play a prominent role in this large-scale enterprise, in partnership with NIH and others. The scope and impact of the Human Proteome Project is comparable to that of the Human Genome Project.

Along with several other centers, BNL is piloting procedures for cost-effective, large-scale determination of protein structures by X-ray crystallography, starting from known coding sequences. We implemented procedures for rapid cloning, expression, purification, and crystallization. We established a publicly accessible web site (http://proteome.bnl.gov) to provide information about our project, including the list of proteins selected as targets, and our progress toward structure determination. Of 14 targets selected initially, 12 proteins were sufficiently soluble for purification, and 11 gave rise to microcrystals. Two of these have produced diffraction-quality crystals, and their structures have been determined. Because of this initial success, we now are implementing a 96-well methodology for each of the steps from amplification through testing for expression and solubility. This should produce a steady flow of proteins for purification. We are working in partnership with scientists at The Rockefeller University and Einstein College of Medicine:

- To analyze the physical properties of the purified proteins,
- To understand the factors involved in obtaining diffraction-quality crystals,

- To establish procedures for generating diffraction-quality crystals for most soluble proteins, and
- To determine their structures.

Intelligent selection of target proteins requires convenient access to vast amounts of information in publicly accessible databases about genes, proteins, functions, structures, family relationships, and evolutionary distribution. In selecting proteins to test in 96-well format, we are developing a local Structural Proteome Database (SPD) to gather the needed information and to present it in useful format on a web interface. Among the information we gather is whether any member of a protein family has been selected for structure determination by any of the structural genomics projects. Thus, the SPD could become a vehicle for coordinating target selection among the different structural genomics projects. As soon as the SPD has reached a stage where it is generally useful, it will be publicly accessible on the web.

If suitable crystals are available, a protein crystallography beamline at the NSLS can collect all of the data needed to determine a structure within a matter of hours. However, converting those data into a fully refined structure usually takes weeks or months of effort by a skilled crystallographer. If an organized center could generate crystals at a rate that would allow the collection of crystallographic data for even a single protein a day, a skilled group of crystallographers would be needed to keep pace in determining the structures. We plan to undertake a focused effort to automate as much as possible the model building and refinement processes, and minimize human involvement. Continual interaction between the scientists attempting to solve structures and those working to improve the structure-solving software should facilitate this development process. Success would substantially reduce the cost of structure solving, both in high-throughput centers and in traditional crystallography laboratories.

OBER support for structural genomics work at BNL came initially from a JGI Functional Genomics Pilot Project, which we augmented in our local restructuring of the Molecular Biology Program, scheduled for peer review in October. We propose to reprogram part of our support for Structural Biology Research toward the structural genomics effort. In partnership with Rockefeller and Albert Einstein Universities, we have applied to NCI for a grant to support further development of structural genomics technologies, and we plan to apply to NIGMS for support to establish a pilot structure-production center. Continued success in establishing the needed technologies would support a rapid scale-up toward a full-fledged Structural Genomics Center.

6.1.5 The Environmental Carbon Observatory (Protecting the Living Planet)

(http://www.face.bnl.gov)

Carbon is perhaps one of the most significant environmental problem of the 21st century. Innovative methods for reducing carbon generation, for sequestering carbon, and for evaluating the effects of carbon dioxide on terrestrial ecosystems are required to solve this problem. Currently, the DOE funds facilities where researchers can study the effects of enhanced CO_2 on ecosystems (FACE Facilities) and which can measure the flux of CO_2 at fixed locations using eddy flux covariance techniques (Ameriflux). These complement other DOE investments such as

the Atmospheric Radiation Measurement (ARM) Program, which quantifies the effects of clouds on the flux of solar and infrared radiation in the atmosphere.

However, a larger network of FACE and Ameriflux sites are required to understand the global effects of enhanced CO_2, at least in a representative set of different ecosystems. That subset of system has been estimated by various researchers to be several dozen sites worldwide. In addition, FACE and Ameriflux sites should be coupled to guarantee that the effects of artificially enhanced CO_2 can be compared directly with the natural fluxes at the same site. Since the terrestrial biosphere is the primary driver for the annual variability of carbon dioxide in the atmosphere this will provide critically important input to models that can be extrapolated to larger scales and to the hotter, wetter climate which is likely in the next century.

A multi-laboratory, multi-agency, and multi-national program is necessary to fully address these issues. BNL has proposed the Environmental Carbon Observatory (ECO) as a candidate for such a program. The ECO will allow researchers to measure the carbon dioxide flux from terrestrial sources around the world, link those measurements to field manipulation experiments, and provide critical input to models of global change and protocols for carbon management. BNL's expertise in the design and management of numerous FACE facilities and our recently acquired expertise in carbon modeling makes BNL an ideal candidate to lead such an effort.

The objectives of ECO are the following:

- Improve predictions of atmospheric CO_2 and climate change.
- Provide a scientific basis for using agriculture, forestry, and natural ecosystem to offset CO_2 emissions.
- Expedite early warning of large-scale, rapid changes in coupled atmosphere-biosphere system.

Although carbon flux and net ecosystem production can be measured at more than 40 eddy-covariance tower sites in the Ameriflux and Euroflux programs, it is not possible to quantify spatial heterogeneity of either the flux or net production at these sites because of uncertain statistical extrapolations to large areas. FACE facilities in several types of ecosystems can predict how those ecosystems will respond to increasing atmospheric CO_2, and how carbon storage in those systems might change. However, the FACE sites do not have well-developed modeling components that can couple the experimental findings to regional analyses of carbon sinks, or predict regional ecosystem-level responses. Furthermore, the ecosystems studied poorly represent the variability of the biosphere. Eddy-flux tower measurements and FACE experiments have great potential to provide the tools for monitoring planetary carbon flux and predicting biospheric responses to climate change if they are augmented and integrated in a coherent program. Well-bounded predictions of both carbon sequestration and atmospheric CO_2 might then be obtained.

ECO will be the first large-scale user facility developed for ecosystem-scale manipulations. The integration of the FACE and eddy-flux tower provides the framework for a broad spectrum of scientific research. Scientists can collaborate in experiments at the same site on topics such as the following:

- Molecular-level controls on proteins regulating photosynthesis,
- Ecosystem-scale controls on carbon sequestration in forest biomass and soils and,
- Linkages via gas exchange with the planetary boundary layer.

In conjunction with other aspects of the US Global Change Research Program, we will be able to model global carbon sequestration and atmospheric CO_2 exchange from the process level upward.

The ECO will be developed from aspects of the current DOE-OBER programs. The Ameriflux and FACE programs are crucial. This initiative requires substantial funding in the following three areas:

- Facility development,
- Facility operations, and
- Research on the terrestrial carbon cycle.

Several dozen ECO facilities would be constructed in ecosystems around the world. Each regional unit would consist of a central intensive core, including a set of permanent eddy-flux towers and FACE experiments. A phased approach to building ECO is envisioned. The first phase would consist of regional units that encompass expansion of the eddy-flux network, integration with the existing FACE experiment, and development of data acquisition and modeling tools.

ECO global-scale analysis requires the ability to integrate research across spatial and temporal scales within each of the regions. Within the BNL FACE program, we are developing models that will describe quantitatively the link between repression of gene expression controlling Rubisco activity at elevated CO_2, to leaf-level net photosynthesis. BNL participates in a second modeling effort that takes leaf-level gas exchange measurements of photosynthesis and other variables, and provides estimates of net production of the forest canopy. A third modeling effort involving BNL is the link between canopy gas exchange and the flux of energy, moisture, and CO_2 between the forest and the atmosphere. ECO creates the ability to provide explicit modeling links across temporal- and spatial-scales. Strengthening our capabilities in terrestrial ecosystem modeling, and developing an integrated framework for modeling across these scales, enables BNL to play a leading role in integrating information from many semi-independent users of the ECO facility.

6.1.6 Tropospheric Aerosol Program (Protecting the Living Planet)

Tropospheric aerosols, suspensions of microscopic particles present in the lower part of the atmosphere, affect human health, visibility, acid deposition, and climate. Recently, the United States adopted new ambient-air quality standards governing the concentrations of fine particles, below 2.5 micrometer (μm) diameter. The focus of the DOE Tropospheric Aerosol Program (TAP) is to accomplish the following:

- Understand the processes that govern the loading, geographical distribution, chemical composition, and microphysical properties of these aerosols.

- Understand and quantify their environmental influences and to represent their effects in models that can be used to develop strategies to meet the new air-quality standards.

The TAP program consists of both research and infrastructure components. BNL proposes to lead the infrastructure element and to play a major role in the scientific program.

BNL is focusing its research activities on the following three areas:

- Advanced characterization of ambient aerosols: total aerosol mass and composition, size-resolved mass and composition size, and composition of individual particles, particle morphology, and surface structure. BNL's approach includes sampling and analysis of semi-volatile particles through activation, impaction, liquid chromatography, and mass spectrometry. These will be combined with BNL's existing field capabilities in sampling and analysis of trace gases.
- New experimental and theoretical methods for investigating new particle formation, particle growth, gas-particle chemical reactions, and equilibrium and non-equilibrium phase changes.
- Novel approaches to representing atmospheric aerosol processes in chemical transport models, including three-dimensional regional chemical modeling.

It is clear that effort also needs to be directed to atmospheric aerosols at the regional-and state-level. Southern California has set an example in which state- and regional-agencies team up research institutions to develop an understanding and model-based representation of air quality that is used in air-quality management. BNL expects to take a lead role in developing such research in the metropolitan New York area.

6.2 Program Initiatives - Science and Technology Mission

In the Science and Technology area we propose seven program initiatives:

- NSLS third phase upgrade
- Expansion of Protein Crystallography at the NSLS
- RHIC Science Center
- Nanoscience Initiative
- Carbon Management
- Combustion Modeling and Simulation
- Biomedical Initiatives

Several of these program initiatives relate to more than one goal of the Science and Technology R&D portfolio, and the basic understanding derived from these new efforts will advance DOE's missions in energy resources and environmental quality. The phased upgrades to the NSLS will assure the cutting edge capabilities of this facility and the Expansion of the Protein Crystallography encompasses a major partnership between the DOE and NIH. The Carbon Management, Combustion Modeling, and Biomedical Initiatives represent significant intra-laboratory collaborations and coordination of resources. The Carbon Management,

Tropospheric and Environmental Carbon Observatory Initiatives are complementary components of research on global climate change and The Nanoscience Initiative focuses on the exciting opportunities for the synthesis of new materials with unique properties, and for fundamental discoveries in this size domain.

6.2.1 NSLS Third Phase Upgrade (Extraordinary Tools)

The third phase upgrade of the NSLS is fully aligned with DOE's objective to provide and maintain our national assets for interdisciplinary research. The NSLS is one of the DOE's critical research facilities for exploring simple and complex systems. This initiative maximizes the scientific output of the facility. The BES program office has indicated that their funding priorities in the out-years will require that the Upgrade project be accomplished by a sequence of smaller projects. NIH has expressed an interest in sharing the cost of this upgrade and contributed $4M in FY1999. Working with BES and NIH, the NSLS will prioritize the components of the Third Phase Upgrade, which are outlined below.

The overall project includes improving two of the 25 beamlines on the UV ring that support strong scientific programs but produce less-than-optimal science because their monochromators are outdated. The upgrades will support state-of-the-art electron spectroscopies (e.g. high electron energy resolution angle-integrated photoemission) resulting from increased photon-energy resolution. The flux at the sample will be greater, at a given photon-energy resolution, because there will be no need to mask the optics.

Eight of the 60 operational beamlines on the X-ray ring will be improved, taking advantage of improvements in X-ray optics and detectors. X-ray mirrors will be replaced on the most productive and well-equipped beamlines of the 2.8 GeV ring used for X-ray spectroscopy, X-ray scattering for chemical and materials sciences, biostructural studies and X-ray imaging.

Improvements to the machine include on photon beam position monitoring systems for UV and X-ray, new rf cavities/transmitters, and three insertion devices for the X-ray storage ring. High-resolution monitors (< 1 micron) will be added to each available port on the machines that independently measure the position of the photon beam as it is delivered to the user.

Four 52.88 MHz cavities on the X-ray storage ring have water-to-vacuum welds, which are a potential problem; two are being replaced. The remaining two will be replaced through the upgrade project. Two additional transmitters will be added to reduce the likelihood of loss or fluctuation of the beam.

Two new X-ray undulator sources will be added and the associated beamlines constructed. These new undulators are based on successful R&D efforts on insertion devices and our experience with a prototype in-vacuum small-gap undulator developed in collaboration with Spring-8. One of the new lines may be dedicated to protein crystallography. New insertion devices also will be installed on X25, halving the gap and period of the existing device, and increasing the brightness by a factor of two without adding heat load on the X-ray optics.

A superconducting magnet energy storage system developed for the U.S. Air Force, is

undergoing tests on the UV ring. If the tests are successful, a larger unit will be obtained for the X-ray ring to reduce the unscheduled downtime caused by voltage transients on the Laboratory's power feed.

The conventional construction includes a 9,400 square foot second floor over the X6 – X16 area of the NSLS, providing space for offices and a conference room. It also includes 6,300 square feet of open space that will be developed by the user community.

6.2.2 Expansion of Protein Crystallography at the NSLS (Extraordinary Tools)

Demand for access to synchrotron radiation for protein crystallography has been accelerating and continues to outstrip availability. With awakening interest in high-throughput determination of three-dimensional structures of all of the protein-folding domains represented in nature, demand will escalate for more capacity for synchrotron crystallography, state-of-the-art instrumentation, semi-automated beamline operation, and highly efficient structure-solving software. The NSLS is the most reliable, economical source of X-rays for protein crystallography, and is ideally placed to satisfy much of the increased demand.

Beamline scientists at BNL are world leaders in developing user-friendly, efficient synchrotron beamlines for protein crystallography. A core group of scientists and technicians constructed and operate two bending-magnet beamlines and a wiggler beamline for protein crystallography, and are collaborating with the Participating Research Teams of two additional beamlines to provide technical and operational support in return for beam time for the general user program. Through support from DOE-OBER, DOE-BES, NIH and the outside PRTs, we are bringing these five beamlines to state-of-the-art reliability and efficiency with modern CCD-based detector systems, and exploring new technologies to improve their effectiveness and efficiency. With additional support, through an emerging partnership between DOE-OBER and NIH, we will construct and operate additional beamlines for protein crystallography and explore new operational methodologies that could eventually replace most of the traditional, expensive visits of teams of crystallographers to collect data.

6.2.3 RHIC Science Center (Exploring Energy and Matter)

Experiments at RHIC will be carried out using several collider detectors, which are designed, built, and operated by international scientific collaborations. The four RHIC detectors have over 800 collaborators from some 90 universities and laboratories representing about 20 countries.

Once RHIC is operational in 2000, approximately 300 visiting scientists will be on site at a given time to coordinate the experiments, operate the detectors, and analyze data while working alongside a Brookhaven staff of about 150 scientists and support personnel. During short periods (e.g. workshops, collaborations, meetings,) an additional 100-200 visitors will be at Brookhaven.

Although the scope of the AGS program is decreasing, there is not enough space at BNL to accommodate such large numbers of visiting users for the RHIC facility. Moreover, since

Brookhaven will be the focal point of a world-wide effort to carry out and analyze these experiments, success requires space at BNL where large groups can work together, meet, exchange ideas, and be in close proximity to the experimental equipment, the computing facility for analyzing data, and BNL's research staff. There is no facility at Brookhaven that can provide this consolidation of the RHIC research activity.

The RHIC Science Center will meet these needs by providing office space, meeting rooms, a conference hall, public computer terminals for visiting scientific staff, an equipment area to house the RHIC Computing Facility, and a lobby suitable for public displays and visitors' orientation.

Construction of the RHIC Science Center will result in a program that can reach its full potential for research excellence and achieve the mission of a unique world-class research machine. We are pursuing avenues of shared financing by federal and state agencies.

6.2.4 Nanoscience Initiative (Exploring Matter and Energy)

Through synthesis and exploration of the properties of materials in the nanoscale domain, Brookhaven is poised to advance this exciting scientific frontier and to enhance its position as a center of excellence. Many advances in the physical sciences rely on our ability to control the structure and composition at interfaces on the nanoscale level, or to control the distribution and composition of nanoparticles. Physical and chemical properties often change dramatically as various forms of self-organized structures form on scales of the order of 100 nm long or less. Similarly, the properties and reactivity of particles often change as the particle size decreases below 100 nm. In several different experiments at BNL, researchers saw manifestations of these changes in the nanoscale region. These include experiments in catalysis, electronic properties, and energy transfer. For example, the catalytic properties of monodispersed doped nanoparticles of magnesium oxide (MgO) change with particle size. The sulfur poisoning of some transition metal bi-metallic catalysts may be associated with the formation of self-organized nanoscopic arrays of molecular assemblies. Molecular clustering that occurs in supercritical carbon dioxide can result in sterotactic control over chemical reactivity. Isolated single particles exhibit a rich phase diagram as a function of particle size, and the growth of metallic overlayers on some transition metal surfaces show self-assembled island structures as a function of coverage. Similarly, the onset of superconductivity in granular films involves the formation of self-organized clusters.

There are also interesting phenomena in the area of energy transfer. The production of solvated electrons from the absorption of high-energy ionizing radiation in silica nanoparticles has important consequences for the treatment and storage of high-level radioactive waste. Nanoscale molecular wires may aid efficient solar energy conversion and storage.

6.2.5 Carbon Management Initiative (Fueling the Future and Protecting the Living Planet)

Carbon management describes a complete portfolio of strategies that might be used to mitigate the effect of anthropogenic emissions of CO_2 to the earth's atmosphere. The role of the

Environmental Carbon Observatory is to address gaps in our knowledge of the global carbon cycle that hamper our ability to predict the following:

- If, and how climate will change,
- The impacts of climate change on agriculture, forestry, and natural ecosystems, and,
- How such impacts on natural ecosystems may moderate or intensify climate change.

The Carbon Management Initiative focuses on very specific aspects of carbon avoidance and carbon sequestration, specifically:

- Use of carbon-free energy sources (e.g., renewables, nuclear, hydrogen produced using carbon-free energy),
- More efficient use of fuels containing carbon,
- Separation and capture of CO_2 from the effluent streams of carbon generators, followed by long-term storage in geological formations or in the ocean, and
- Long-term capture of atmospheric carbon in terrestrial- or oceanic-ecosystems.

The first two strategies reduce the amount of CO_2 produced in energy conversion systems, "carbon avoidance". The third and fourth deal with CO_2 once it is produced “carbon sequestration”.

Brookhaven National Laboratory can contribute significantly to these strategies in the following specific areas:

- Energy efficiency, renewable energy, and physical and chemical separation, capture and sequestration of carbon from effluent streams,
- Sequestration of atmospheric carbon in terrestrial ecosystems, and
- Enhancement of net oceanic uptake of carbon from the atmosphere.

Efficiency, renewables, and physical and chemical capture are grouped because of the considerable overlap of competencies BNL can focus on these approaches to carbon management. The primary disciplines involved are materials science, chemistry, mechanical engineering, and chemical engineering. For energy efficiency and renewables, Brookhaven will emphasize several intensive efforts in very specific areas. The major thrusts for Brookhaven will be materials, second-law efficiency, and catalysis.

Carbon management can be viewed as a materials problem. Brookhaven will build on current expertise in magnetic and high-conductivity materials, corrosion protection, cementitious materials, and polymers to address high-priority problems in geothermal energy, advanced power systems, and separating CO_2 from multi-gas streams.

The two major objectives of catalysis in carbon management are converting fuels to more useful energy forms, and promoting chemical reactions that facilitate the removal of CO_2 from effluent streams. Brookhaven will focus on catalytic and biocatalytic reduction of CO_2, catalysis

of biomass conversion to chemicals or fuels, catalytic reforming and photochemical conversion of CO_2 and methane to useful compounds, biochemical upgrading of crude oil, improved catalysts for fuel cells, and advanced combustion systems that use unconsumed intermediaries to produce effluent streams rich in CO_2 facilitating its removal.

For example, Brookhaven is strategically placed to advance basic knowledge in:

- Heterogeneous catalysis and photocatalysis to produce carbon monoxide-hydrogen mixtures (synthesis gas) for use as feedstock,
- Fundamental studies of transition metal- and porphyrin-promoted carbon dioxide reduction, and,
- Understanding and improvements of catalysts for fuel cells.

Second-law efficiency denotes the ability of energy-conversion systems to maximize the quantity, as well as quality, of useful energy derived from a given amount of fuel. BNL will emphasize fuel cells, advanced battery systems, thermophotovoltaics, and community-level integrated systems to maximize the use of electrical and thermal energy derived from co-generation.

We will use our unique abilities and facilities for this work, including X-ray scattering techniques developed to study in-situ surface processes, in-situ Fourier Transform Infra-Red (FTIR) spectroscopy, UV photoionization, neutron scattering, scanning tunneling microscopy (STM), and in-situ X-ray absorption spectroscopy (XAS). These techniques are a powerful combination for in-situ studies of surfaces and surface reactions in catalytic and electrocatalytic systems.

The integrated program will address major aspects of electrocatalysis, and new catalytic systems will be explored based on monolayers, multilayers, and nanoparticles of bimetallic and alloy systems.

This initiative also involves collaboration with SUNY Stony Brook's Department of Materials Science and Engineering and with the Center for Advanced Thin Film Technology at SUNY-Albany, and is responsive to a New York State initiative in this area.

6.2.6 Combustion-Related Simulation and Modeling Initiative (Fueling the Future)

As part of the Strategic Simulation Initiative in combustion, we propose expanding our effort in Fine Continuum Simulation Studies, Direct Numerical Simulation Modeling, Variational Transition-state Theory Calculations of Rate Constants, Application of Quantum Chemistry to Potential Energy Surfaces for Elementary Combustion Reactions, and Mechanism Reduction.

Front Tracking is ideal for studying the breakup of a jet and the distribution of particle sizes. The method offers complete control over numerical diffusion and was validated through very demanding multiphase- and fluid-instability studies for fluid mixing. Current studies with

this code involve jet instabilities, fluid instabilities, acceleration driven instabilities, and fluid mixing layers.

We also propose developing a computationally efficient, massively parallel, spectral element, Direct Numerical Simulation model to examine the development of temporal and spatial patterns of turbulent flow fields in combustion, and improve our understanding of turbulence structures and the effect of such structures on the turbulent combustion processes.

In conjunction with *ab initio* electronic structure calculations of the features of potential energy surfaces, a third approach we will use is the Polyrate program (University of Minnesota) variational transition-state theory calculations of rate constants for selected elementary combustion reactions. One objective of these calculations is to provide a theoretical interpretation for the experimental results for the same reactions obtained by the radical-radical kinetics effort by the BNL Gas-Phase Molecular Dynamics group.

To address the kinetics of key radical species in combustion processes we will exploit contemporary electronic structure techniques to evaluate the necessary molecular structural and energetic information. Specific target systems include free-radical-based systems such as atomic oxygen reacting with methyl radical, currently under experimental investigation by the BNL Gas-Phase Molecular Dynamics group.

Finally, gas phase mechanisms of varying degrees of complexity, describing the photochemistry of the lower atmosphere, are used routinely to formulate ozone-control strategies. A mechanism in a three-dimensional transport model is used to accomplish this task.

We will investigate a direct a link between the concentrations measured in field programs and the process level information that we are trying to elucidate. We will derive simple analytic relations that reproduce the results obtained from a full photochemical mechanism. For example, the sensitivity of the O_3 production rate to hydrocarbons and NO_x is a simple function of a single variable that describes the removal pathway of free radicals. We will evaluate these sensitivities because of their relevance to ozone control strategies and the determination of whether it is more effective to reduce emissions of NO_x or hydrocarbons.

6.2.7 Biomedical Initiatives (Protecting the Living Planet and Exploring Matter and Energy)

We propose several new biomedical efforts over the next five years, which will consolidate resources in our biomedical programs.

Laboratory for Cell Biology, Behavior, and Functional Genomics will provide a mechanistic and functional framework for PET- and MRI-imaging studies including human and animal studies in addiction, aging, drug development, and cancer. It will enhance current capabilities in microdialysis, electrophysiology, and *in vitro* binding. It will combine with imaging to delineate molecular and cellular effects of BNCT and microbeam radiation and advance the NASA Space Medicine projects. Manned space flight beyond the Earth's protective magnetic field will expose astronauts to new radiation burdens, including high-energy, high

atomic number particles (HZE radiation) with poorly understood radiobiological effects. These effects include neurobehavioral changes resulting from the destruction or damage of brain cells that may accelerate the effects of normal aging on cognitive, emotional, and motor abilities. We will use the same facilities to investigate these issues in animal models. This research area ties in with both our interests in normal aging and in cancer treatment and diagnosis. We will use the AGS where irradiation facilities for HZE radiation are uniquely available.

We will evaluate and validate new methods for assessing gene delivery and the functional activity of specific gene products (receptors, enzymes, transporters) in normal and genetically altered animals in conjunction with the new DOE-OBER funded animal PET. These studies would be significantly enhanced by the acquisition of a dedicated high-field animal magnetic resonance imaging instrument that can make functional and spectroscopic measurements, and modern digital autoradiography equipment.

Cancer Research: We plan to build on our current strengths in nuclear imaging, radiation therapy, and high contrast diagnostic imaging (NSLS) to consolidate Brookhaven's efforts in cancer research. PET imaging will be further developed to characterize the molecular properties of human tumors, to monitor molecular, cellular and metabolic effects of BNCT, and to map drug distribution and kinetics to understand the therapeutic- and side-effects of anti-cancer drugs and BNCT. Imaging will be used to investigate the molecular mechanisms responsible for the sparing effect of microbeam radiation therapy (MRT) in normal tissues, the mechanisms accounting for its toxicity in malignant tissue, and the potential clinical applications to malignant brain tumors. Because early detection of tumors is important in outcome, we will pursue the development of high-contrast mammography and other forms of imaging, building on promising initial studies using the unique capabilities of the NSLS. In addition, when the Proteome Initiative is underway and proteins unique to tumors are identified, this new knowledge will be used to develop strategies to diagnose and treat cancer.

We will focus on developing better tools to diagnose and treat breast cancer. Two different approaches to diagnosis are being evaluated, high-contrast mammography using the NSLS, and radioisotope labeled compounds for enhancing sensitivity for its early detection.

Early diagnosis of breast cancer is associated with a longer survival and a higher likelihood of a complete cure. Research methods using the NSLS should have a contrast at least 10-fold better than present mammograms, enhancing the sensitivity for early detection.

A parallel approach will use positron emission tomography (PET) as an imaging modality to detect malignancies on the basis of their biochemical characteristics, help determine a tumor's stage, and provide information on its characteristics which are currently available only by tissue biopsy.

Malignant cells grow out of control because the normal biochemical processes regulating growth are disrupted. PET measures sugar metabolism with a tracer called FDG. It is used to visualize sugar metabolism by tumors, to locate metastases, and to monitor response to therapy. Many breast tumors depend on estrogen, and the metabolites of estrogens may well change the control of DNA transcription, leading to uncontrolled cell growth. An enzyme, catachol-o-

methyltransferase (COMT), which is elevated in malignant breast tumors and, in some tumors, is under genetic control, breaks down estrogen metabolites. BNL developed a compound labeled with ^{18}F that binds to COMT. PET studies are underway to detect the distribution of COMT in breast tissues. Our studies will focus on validating this approach to understand the role of COMT and estrogen metabolism in cancer breast, to diagnose breast cancer at an early stage, and to design treatments and monitoring therapy.

We will investigate the use of radioisotopes, such as (Sn-117 nDTPA), for the palliation and treatment of bone metastases that are frequent in patients with advanced breast cancer. We will explore using isotopes produced at the BLIP, coupled to monoclonal antibodies that are directed against antigens abundantly expressed in breast cancer cells. In addition, BNL recently developed immuno-conjugates labeled with certain positron emitters that may be useful in the early detection of breast cancer using high resolution PET imaging. Molecular engineering could enhance the cytotoxic potential of radiolabeled antibodies. We are working on fusing viral proteins to antibodies to increase the uptake of the labeled conjugate into tumor cells that could be used to image or destroy the tumor.

Brain metastases are not as frequent as bone metastases but they produce tremendous morbidity and compounds which we are currently using for BNCT of primary brain tumors, glioblastoma, are not suitable for metastatic breast cancer cells. However, several new compounds which show great promise for accumulating in breast cancer cells could be used as the basis of BNCT for brain metastases; we will pursue funding from DOE and other sources to test the feasibility of this approach.

Finally, the full exploitation of BNCT for cancer treatment will require more economical, safer sources of neutrons. BNL is acquiring from Northrup-Grumman a small 2 MeV tandem cascade accelerator, with 8 mA beam current. When it arrives and is commissioned it will be used to assess the feasibility of producing and using neutrons for BNCT.

PET Instrumentation: One of the very first PET instruments was designed and built at Brookhaven in the early 1960s. Because of the remarkable growth of PET research, and because of Brookhaven's leadership in developing PET radiotracers, we are initiating an inter-departmental collaboration to design and develop new specialized PET imaging instruments, based on innovative designs and special applications (e.g., positron-detector probes for freely moving animals, arterial blood detectors, and rectilinear scanner for rapid kinetics in small animals).

In the PET Imaging Program, we have funded protocols to fully occupy two PET scanners. The older PET scanner is difficult to keep running, will probably not operate much longer. Already there is considerable down time for repairs. We are seeking funding to replace this scanner with a new PET instrument.

Our main cyclotron for positron emitter production is now 20 years old; it eventually will need to be replaced with a modern accelerator. A modern instrument will have a negative-ion capability that is superior for positron-emitter production and will be computer controlled and not require advanced skills to operate.

Cyclotron for Radioisotope Research, Development and Production: We will also pursue funds for a cyclotron with medium- to high-energy range and high beam-current (30-70 MeV protons and 500 μA or greater). This machine would be used to develop and produce new medical radioisotopes for diagnostic and therapeutic applications, and to develop high-power targets for producing larger quantities of both PET and non-PET radioisotopes. This cyclotron would be available year-round for medical radioisotope research and production, and for training. A new building to house the cyclotron and associated isotope processing may be required, depending on the size of the cyclotron and the scope of the project.

6.3 Program Initiatives - Energy Resources Mission

Our initiatives in Energy Resources focus on clean affordable power and particularly on advanced power systems and preserving critical infrastructures

6.3.1 Nuclear Energy

The DOE implemented a Comprehensive National Energy Strategy. Nuclear energy research and development is a major part of this strategy since it can help to reduce US greenhouse gas emissions.

DOE's new approach to nuclear energy R&D, developed by the Office of Nuclear Energy, Science and Technology (NE), has two elements that are aligned with BNL expertise: the Nuclear Energy Research Initiative (NERI), and Nuclear Energy Plant Optimization (NEPO). BNL received a contract on "A Proliferation Resistant Tight Lattice BWR Fuel Core Design for Increased Burn-up and Reduced Fuel Storage Requirements".

NEPO is being developed by DOE and the Electric Power Research Institute to pursue technologies that foster life-extension and optimize electrical generation from existing power plants. This could reduce global carbon emissions by enabling existing Light Water Reactors to continue to operate beyond their license period. For the NEPO initiative, we will pursue programs on operational improvement, aging management, and high burn-up fuel.

6.3.2 Integrated Energy - Economic-Environmental Assessment and Policy Support

Brookhaven National Laboratory, a leader for over two decades in energy assessment and model development, is proposing an initiative to support two areas of current emphasis by United States and foreign policy-makers: global climate change, comprehensive energy and environmental assessments. This initiative builds on work developed at BNL, combined with private-sector contributions, to create a public-private partnership that can address a wide range of analytical options and technical solutions to the issues defined by the public debate on global climate-change, carbon management, and international environmental security planning.

The primary tool is MARKAL-MACRO, developed at BNL in the early 1970s. It is a technology specific, data-rich optimization model that will provide least-cost energy system solutions under specified constraints to support policy and planning decisions. MARKAL-

MACRO can answer specific questions in conjunction with other models, such as air quality dispersion models, and Geographic Information Systems (GIS) representations. Areas that can be examined include projections of greenhouse-gas emissions under CO_2 constraints, evaluation of emission-reduction options, ranking of technology portfolio options, or specification of the environmental impacts of alternative energy futures for a country or locality.

The current primary sponsors of this work are the DOE's Offices of Policy and International Affairs and Nuclear Energy and the EPA Offices of Policy, Planning and Evaluation, Air Quality, and International Activities, and EPA Region 2.

6.3.3 Smart Cities

With the growing age of our infrastructure and the cities that rely on it, BNL is working to develop a research plan to link information processing, advanced instrumentation, and materials technology with improved safety, security and efficiency of our cities. This effort will include participation by universities, local-, state-, and federal-government authorities, and businesses. We will develop early demonstration projects to establish the efficacy of "self-monitoring" structures and facilities, based on available or prototype measurement techniques and sensing systems. Research would focus on advanced development of built-in monitoring and associated intelligence capabilities. State of life, need for corrective action, emergency response, preventive maintenance, and environmental threats, will be rolled up into forecasting decision-tools for city managers and, eventually, for public communication.

6.3.4 Transportation/Infrastructure

Over the last decade, federal and local governments identified the growing crisis in the nation's transportation system and other infrastructure systems. The nation's intermodal transportation systems, rail, air and marine, are overused and under-maintained. The associated infrastructure, including bridges, tunnels and utilities, is reaching the end of its design life expectancy. It is in the national interest to aggressively explore new technological solutions to these old problems. In addition, technical capabilities in the BNL's Information Technology Division and the Department of Advanced Technology are addressing computer security and support for emergency and first responders.

BNL, Polytechnic University, and RPI have proposed to the NSF an Engineering Research Center (ERC) in "Advanced Polymer Technology Applications to Infrastructure". Discussions are underway with the U.S. Coast Guard and the private marine sector to support research into human performance and ship safety. Our past effort in modeling automobile traffic will be revisited to evaluate a new role for BNL in collaboration with PNNL and Battelle to support the US Intelligent Transportation Program

A joint research agreement has resulted in a proposed five-year program on sustainable transportation and its impact on fuel efficiency and environmental quality. Dialogue also is under way that will lead to a new undergraduate and graduate program in human factors, led by BNL researchers.

6.4 Program Initiatives - National Security Mission

DOE provides technical leadership for national and global nonproliferation and nuclear safety. BNL's experience in developing nuclear-, chemical-, and biological detection, in measurement technology (laser spectroscopic systems, neutron and gamma measurements), in exercises with the New York City Office of Emergency Management (NYC-OEM), and in international nonproliferation activities, collectively provide the basis for broad-ranging support on national and global security issues. BNL will develop, coordinate, and participate in multi-laboratory programs to help prevent the proliferation of nuclear-, radiological-, chemical-, and biological-weapons, such as placing effective, advanced, integrated controls on critical materials in the Former Soviet Union and in other vulnerable states. We will focus our biotechnology expertise to improve emergency response and mitigation, and continue interactions with NYC-OEM. BNL will develop technologies and tools to protect and ensure the integrity of US critical infrastructures against terrorist attack.

6.4.1 Center for International Security

A Center was established to work at the interface between technology and policy in international security. This effort will be funded by private foundations and will complement the existing technical work in security currently funded by the Department of Energy.

The Center's mission is to encourage another generation of technically trained people to enter this exciting field, to enhance the understanding and teaching of this subject in academia, and to enrich our staff and programs.

Programs at the Center will include summer institutes for students, a visiting intern program for academics, a senior visitor's program for experts in the field to interact with our staff, and workshops on current topics, with nationally recognized lecturers, resulting in a series of written proceedings.

Table 4 – Resource Projections for Laboratory and Program Initiatives

Brookhaven National Laboratory Initiatives FY 99 to FY 04 Total Estimated Costs in FY 1999 Dollars (Millions)	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
NSLS DUVFEL Facility [1]		TBD	TBD	TBD	TBD	TBD
Muon Collider and Storage Ring Neutrino Beam Study [2]		0.2	0.4	0.6		
Data Intensive Computing [3]	0.4	0.5	1.2	3.0	5.0	5.0
Environmental Carbon Observatory [4]	0.5	5.0	11.0	20.0	33.0	33.0
Human Proteome [5]	0.7	1.3	2.5	3.0	4.0	4.0
Tropospheric Aerosol Program	0.1	0.2	0.7	3.0	8.0	8.0

(1) TBD: To be determined
(2) Laboratory Directed Research Request future resource needs are to be determined.
(3) FY 99 and FY 00 are LDRD funded
(4) This is the request from DOE. Other partners will be sought
(5) Funding will be sought from NIH

Brookhaven National Laboratory – Program Initiatives FY 99 to FY 04 Total Estimated Costs in FY 1999 Dollars (Millions)	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Protein Crystallography at NSLS	4.0	4.0	4.0	5.0	5.0	5.0
RHIC Science Center				1.6	10.0	8.2
Nanoscience Initiative [6]		0.1	TBD	TBD	TBD	TBD
Carbon Management Initiative		0.1	0.5	1.0	1.0	
Combustion Related Simulation			0.5	1.0	2.0	2.0
Biomedical Initiatives		TBD	TBD	TBD	TBD	TBD
Cyclotron Isotope Research Center			7.0	10.6	6.0	
Nuclear Energy Research	0.2	2.0	2.5	2.7	3.0	3.0
Integrated Economic Environmental Assessment and Policy	0.3	0.3	0.5	0.5	0.5	0.5
Smart Cities	0.0	0.2	1.0	1.2	1.4	1.4
Transportation and Infrastructure	0.6	0.8	1.0	1.0	1.0	1.0
Center for International Security	0.0	0.3	1.0	1.2	1.3	1.3

(6) FY 2000 LDRD to determine scope and resource needs.

7.0 Operations and Infrastructure

The Department of Energy's Office of Science (SC) established performance expectations for the Laboratories. Brookhaven National Laboratory, in conjunction with the Department of Energy, established Critical Outcomes in Communication and Trust, Environment, Safety and Health Excellence and Environmental Stewardship, Leadership, Infrastructure, and Business Excellence that drive our improvement agenda to meet these expectations.

The goal of the Laboratory's operations, infrastructure, and technical support services is to achieve these Critical Outcomes and enable the safe and efficient realization of BNL's scientific missions. The Science and Technology Critical Outcome itself highlights the pivotal role of the support operations: "…deliver innovative, forefront science and technology aligned with DOE strategic goals in a safe, environmentally sound, and efficient manner…"

BNL is implementing Performance Based Management (PBM) in all of it's activities to fully support our improvement agenda, deliver on our Critical Outcomes, and meet the Performance expectations of the DOE. We are establishing the next-generation Management Systems throughout the Laboratory, including Integrated Assessment with strong emphasis on meaningful Self-Assessment to ensure success in fully implementing PBM.

Facility Use Agreements (FUA) are aspect of Performance Based Management, and essential for defining ownership. The Agreements document the operating conditions that must be met by the facility's owners, users, and support organizations. FUAs will be executed between the Deputy Director for Operations and facility owners. Facility requirements flow down from the owners to the users through facility-specific agreements, as appropriate, between the facility owner and the user. Through a "Fee-for-Service," facility owners can choose the type, quantity, timing, and the provider of support services. Facility owners' self-assessments help them determine the services necessary for smooth, efficient, safe, and compliant operations. Support services range from consultation on waste-generator issues, to work-site safety evaluations, to office space, power, engineering support, and include technical assistance on the self-assessment processes or in determining corrective actions.

The Laboratory adopted the Standards-Based Management System (SBMS) developed and used at Pacific Northwest National Laboratory (PNNL). The SBMS will be fully implemented by the end of FY2000. Existing BNL manuals have been converted and are now provided on-line. When complete, the SBMS will provide Web-based access to all Laboratory-wide policies, expectations, standards of performance, procedures, and guidelines. Several revised documents are already on-line and in use to familiarize employees with the value and use of the SBMS products.

Annual Self-Evaluation and process improvements are two important aspects of Performance-Based Management. The Laboratory annually evaluates its performance relative to each of the Critical Outcomes, Objectives, and Performance Measures using the metrics and weights identified in the DOE-BSA Contract. This Annual Self-Evaluation is prepared from a roll-up of the Department and Division Self-Evaluations.

Process improvements involve two levels, Department/Division and Laboratory-wide. The Laboratory's Annual Self-Evaluation is the primary mechanism to identify and prioritize Laboratory-wide initiatives for improvement and to modify the Critical Outcomes, Objectives, and Performance Measures for the next performance period. Organizational Self-Assessments identify and prioritize improvements at Department, Division, or Directorate levels.

New management systems and improvement activities are included in the FY99 Laboratory Management Plan. This Plan includes all the improvements and performance measures associated with the Critical Outcomes, as well as improvement activities important to the Laboratory.

7.1 Environment, Safety, Health and Quality (ESH&Q)

The Environment, Safety, Health, and Quality (ESH&Q) Program at BNL supports the Laboratory's aspiration to be the Department of Energy's premier fundamental science laboratory. Excellence in environment, safety, and health protection must be achieved to accomplish this objective. Our new ES&H organization and associated management systems will provide the highest quality, most effective and efficient products and services to its internal and external customers to support BNL's mission. In so doing, the Laboratory will meet the critical outcomes related to its science and technology mission.

The Objectives and Performance Measures associated with the Critical Outcome for ES&H excellence are the foundation to communicate expectations for ES&H and performance; develop ES&H roles, responsibilities, accountabilities, and authorities for managers and workers, and incorporate ES&H expectations into work plans and individual performance evaluations.

ES&H activities are an integral part of all work at the Laboratory. A set of unified ES&H and operational management systems are being established to ensure that work is accomplished in a safe, environmentally responsible manner by carefully applying controls tailored to the work. ES&H activities are integrated into the work during the planning phase. This approach will enhance line ownership of ES&H performance, result in more effective and efficient ES&H technical support services, and shorter cycle times for scientific exploration and construction projects. Managers responsible for work are expected to understand the associated hazards, establish appropriate control measures before work is started, and ensure appropriate control of all workplace risks. Technical ES&H support staff will assist managers in meeting these responsibilities as "purchased services" and will be paid directly from project or research funds. The ESH&Q Directorate will give project managers and line organizations the maximum possible control over their costs while ensuring that operations comply with all applicable ES&H requirements.

Integrated Safety Management (ISM) is one notable element of a comprehensive ES&H Program. In FY99, several initiatives were started and several continued in order to improve the ES&H and operations infrastructure:

- Implement Standards Based Management System (SBMS) elements to meet ISMS verification in FY 2000. SBMS is the primary means of documenting the process and systems underpinning BNL's ISMS.

- Improve in-line self-assessment of ES&H, operational, and programmatic performance. A primary responsibility of line managers is self-assessment of all aspects of work.
- Re-engineer the Commitment and Corrective Action Tracking System (CCATS), which will provide management with ready access to the status of BNL's commitments to DOE, regulators, and other stakeholders.
- Improve the system for prioritizing ES&H and Infrastructure needs.
- Improve work planning in scientific programs and routine work. The intent is to ensure early and appropriate integration of ES&H and operational performance expectations into all the work of the Laboratory.
- Re-engineer the Radiological Control Program to include a new Laboratory-wide Radiation Control Program, and reorganization of radiological services provided to the Laboratory.
- Reduce the frequency and severity of workplace injuries.
- Improve monitoring of the amounts and locations of hazardous chemicals in BNL workplaces.
- Examine the existing set of ES&H and Conduct-of-Work Standards and Requirements to ensure that these are appropriate requirements, policies, and procedures for all hazards in the workplace.
- Review existing ES&H and Operations Management Information Systems to address ES&H and operational requirements, and to control costs, and risks in an effectively and efficiently.
- Issue a Laboratory-wide policy to emphasize BNL’s commitment to environmental compliance and stewardship.
- Work with DOE and EPA to develop and establish a fully integrated Environmental Management System that builds upon, and improves, existing systems. This system will be consistent with the International ISO-14001, and BNL will seek certification to the standard in FY 00-01; this will result in improved environmental performance.
- Establish an Independent Oversight office, reporting directly to the Assistant Laboratory Director for ES&H and Quality, to verify that the line Self-Assessment programs meet expectations and to conduct independent studies or investigations upon request.
- Establish a formal Price Anderson Amendment Act (PAAA) Program to identify and evaluate non-compliance with nuclear safety rules.
- Develop a formal Laboratory-wide lessons-learned program to identify, analyze, and disseminate the findings across organizations.
- Develop and implement an Environmental Compliance Representative Program to provide technical support that meets our commitment to EPA for a rigorous review of processes generating waste, and that promotes early integration of environmental compliance and pollution prevention into projects.
- Identify and resolve environmental vulnerabilities highlighted by the Facility Review Project.
- Integrate and improve BNL’s groundwater protection program.

The overall integration of ES&H into operational activities took a significant step forward under BSA's leadership. BSA laid out a sound, systematic approach to develop the next-generation management systems for BNL. These systems are fact-based, and their implementation has been consistent, though there are gaps in some areas. There is a clear and significant trend in improvement.

7.2 Environmental Management

The Critical Outcome for Environmental Stewardship at BNL reflects our commitment to the environment and to cleanup of the Laboratory.

Environmental management at BNL is focussed on remediating and restoring the environment, managing and minimizing waste, decontaminating and decommissioning facilities, and effectively and proactively monitoring our impacts on the environment. The Laboratory's goal for improving environmental stewardship is to integrate these four key elements of our environmental programs and establish a link to the scientific organizations to enable them to perform research in an environmentally benign manner.

Our recent focus in the environmental restoration and waste management programs is on completing several environmental assessments, source-remediation, and the management of research-generated wastes. We have installed many groundwater-monitoring wells, sampled and analyzed the water, excavated underground storage tanks, and formalized a waste-management program that encourages minimizing waste and discourages its stockpiling.

7.2.1 Environmental Restoration

Major cleanup activities will be completed in 2006. Soil and groundwater remediation and decontamination, and decommissioning of the Brookhaven Graphite Research Reactor (BGRR) also will be completed by 2006. We will proactively remediate contaminated areas safely, within established schedule and costs, and in a way that we are able to accomplish the following:

- Prevent or minimize human exposure to contaminated groundwater and soils, keeping exposure levels as low as reasonably achievable;
- Prevent or minimize the leaching of, and migration of, radiological and chemical contaminants in soils, and
- Prevent or minimize the uptake of contaminants by ecological receptors.

Soil and sediment contamination, primarily at the former Hazardous Waste Management Facility and in the Peconic River bed, will be remediated by the year 2004. The Laboratory will continue to rigorously investigate the quality of the groundwater by comprehensive modeling and by eliminating environmental vulnerabilities (e.g. cesspools). Public water was provided to homes south and east of the site to assure the quality of the community’s drinking water. Several groundwater remediation systems are operating. Additional systems will be installed both on- and off-site and will be operated as long as necessary to achieve the cleanup goals.

7.2.2 Waste Management

BNL will properly manage and minimize wastes to achieve site-wide control of regulated waste and eliminate stockpiled waste. We will achieve this by the following:

- Ensuring ownership of waste and assisting generators with cost-effective support for disposal,
- Assigning ownership of legacy waste and pursue its disposition in a project-oriented manner,
- Evaluating all processes for emissions and effluents and for waste generation potential,
- Aggressively pursuing avoidance and minimization of wastes, and
- Creating a Laboratory framework for ownership of all waste and ensuring that none is created without adequate funding and a pathway for its disposition.

BNL implements a comprehensive Pollution Prevention (P2) program to reduce the quantity and toxicity of wastes generated on-site. The program is structured to evaluate and reduce waste generation at the source. All types of waste are targeted for reduction, including radioactive-, mixed-, hazardous-, and solid-wastes. Processes and waste streams are assessed to identify opportunities for preventing pollution based on several priorities, including environmental risk, health risk, and cost.

BNL's P2 Program supports the use of systems to provide accurate and current waste-stream-specific information. Opportunities for preventing pollution have lead to a steady decline in the quantities of hazardous-, mixed-, and radioactive-wastes generated from routine Laboratory activities. BNL reduced routine hazardous waste by 54%, routine mixed waste by 67%, and routine radioactive waste by 10% as measured from the DOE-established baseline year of 1993.

7.2.3 Environmental Monitoring and Integration

The Laboratory will integrate the multi-media environmental monitoring program to enhance the coordination, efficiency, and effectiveness of Environmental Services, Environmental Restoration and Waste Management Divisions. This approach will improve responsiveness to stakeholders' concerns and increase community awareness of the Laboratory's overall Environmental Management programs, and will ensure that we manage and protect public health and safety and restore natural resources at BNL in a coordinated fashion.

Our initial focus has been to optimize and integrate the groundwater-monitoring program. We developed our in-house capabilities and are establishing close working relationships between environmental management and scientific research entities. The six key elements of our strategy are the following:

- Enhance responsiveness to the community for information by providing timely access to quality data,
- Integrate all environmental monitoring data into one database,

- Establish and implement a site-wide Environmental Quality Assurance Program,
- Establish a consistent set of sampling procedures to ensure that quality data are acquired,
- Install additional wells to monitor active facilities and verify that the measures are designed to prevent groundwater contamination are effective, and
- Enhance compliance programs (e.g., Underground Injection Control (UIC), underground tanks) to ensure hazardous materials are properly managed

Table 5 – ESH, Infrastructure and Environmental Management Resource Projections

Environmental, Safety, Health and Infrastructure Resource Projection (FY 99 Dollars in Millions)						
FUNDING	**FY99**	**FY00**	**FY01**	**FY02**	**FY03**	**FY04**
ESH Operating						
Laboratory (SM/G&A)	2.9	1.5	(a)	(a)	(a)	(a)
Department & Division	35.0	36.8	37.4	35.0	32.4	34.1
ESH Capital Equipment	0.3	.3	0.3	0.3	0.3	0.3
ESH Line Item	0.5	3.0	3.7	8.2	7.4	10.0
ESH GPP						
KA Landlord	3.9	0.0	0.0	(a)	(a)	(a)
KA Program	0.0	0.0	0.4	(a)	(a)	(a)
KB Landlord	0.0	3.4	1.6	(a)	(a)	(a)
KB Program	0.0	0.0	0.4	(a)	(a)	(a)
KC Program	1.1	0.9	0.1	(a)	(a)	(a)
KP Program	0.0	0.0	0.0	(a)	(a)	(a)
ESH AIP						
KA	0.0	0.0	0.0	(a)	(a)	(a)
KB	0.0	0.0	3.4	(a)	(a)	(a)
KC	0.4	8.0	0.9	(a)	(a)	(a)
KP	0.0	0.0	0.0	(a)	(a)	(a)
Infrastructure Line Item	0.8	3.9	2.6	6.5	16.2	16.0
Infrastructure GPP	2.0	1.7	3.3	(a)	(a)	(a)
Environmental Management (EM) Funded						
Remedial Actions	15.4	14.9	15.5	14.6	16.4	22.7
BGRR D&D EM-40	2.6	0.1	5.6	6.6	4.5	5.6
Legacy Waste Disposal	1.1	2.8	2.4	2.1	(b)	(b)
Program Management	2.7	2.7	2.7	2.8	2.3	2.1
BGRR D&D: Office of Science	1.8	4.9	0.2			
Waste Management Operations (EM-30)	7.0	8.1.8	5.8	(b)	(b)	(b)

(a) To be determined (b) Funding responsibility transfer to programs.

7.3 Community Involvement and Public Affairs

Over the next five years, the Laboratory will be recognized as a good neighbor, valuable employer and community asset. To achieve this goal, we will expand our community involvement process to line managers across the laboratory, more efficiently and effectively target our communications to stakeholders, develop management systems to systematically collect stakeholder feedback, develop an intranet for employee communications that will include opportunities to access news articles and broadcasts via the web, and add anew research base and measurement criteria to our strategic communications plans.

The Department of Energy's Office of Science expectations for outstanding science and stewardship of a viable science capacity includes excellence in relations with stakeholders. The Laboratory clearly understands that scientific advancement relies on excellent communications and community relations, and that a commitment to ES&H is the pathway to community support. Our Critical Outcome in Communication and Trust is to ensure that we are recognized as a community asset, a good neighbor, and valued employer.

Through our Community Interaction and Public Affairs program we will enhance the responsiveness and effectiveness of our communications to internal and external stakeholders

Our annual Strategic Communications Plan describes activities across the various functions, disciplines, projects, and programs at BNL. The Laboratory will build on these activities and include the input of internal and external stakeholders in its future plans. Over the past year, the Laboratory has initiated several new efforts.

- BNL Web Site: The BNL web site was enhanced and made more accessible to the public. We will continue to update the web to provide current, complete, and timely information about the Laboratory.
- Environmental Fair: To supplement our extensive environmental communications process and ensure that environmental information is widely accessible to the general public, BNL will continue to hold its annual environmental fair. The first Environmental Fair last year attracted more than 3,000 visitors.
- Advertising: BNL has joined other major Long Island-based organizations to sponsor Newsday's "Long Island - Our Future" series, which includes full-page advertisements celebrating accomplishments at BNL, showcasing researchers, reinforcing awareness of the economic benefits of the Laboratory, and highlighting progress in environmental remediation.
- Monday Memo: An employee electronic newsletter was created to inform employees about policies, science developments, environmental issues and progress, and other significant information. Employees are encouraged to ask questions and provide feedback.
- National Press Campaign: The Laboratory has launched a proactive and positive national media campaign, emphasizing the importance of the Relativistic Heavy Ion Collider (RHIC), to promote our exciting research and scientific accomplishments.

- Editorial board meetings with daily and weekly newspapers continue to generate interest in BNL and its research and to facilitate accuracy in reporting. We will expand our efforts to disseminate information about the world class science at BNL through exhibits and promotional events at scientific conferences and trade shows.

We also are creating opportunities for community involvement in Laboratory planning and decision-making processes. We prepared a Community Involvement Plan with input from the community, employees, and representatives of the U.S. Department of Energy. This plan describes an integrated, Laboratory-wide approach to community involvement, and we will implement the actions across the Laboratory in the following ways:

- Develop a Community Involvement Handbook for line managers that will translate the plan into how-to instructions for identifying and addressing the need for community involvement.
- Train line managers and Laboratory personnel on how to use the Handbook.
- Develop a program and project-level Community Involvement plans.
- Incorporate community involvement goals and requirements in organizational plans and individual performance agreements across the Laboratory.

The Laboratory formed a Community Advisory Council (CAC) to ensure that the ideas, interests, and concerns of the community are considered in our decision-making processes. The CAC meets monthly and represents a diverse array of internal and external stakeholders, and is an important source of information about community concerns about the Laboratory.

We are committed to achieving a better understanding between the Laboratory and external and internal stakeholders. BNL completed surveys of its employees and members of the community living on the east-end of Long Island and within a fifteen-mile radius of the Laboratory to gain an understanding of stakeholders' attitudes and knowledge about BNL. These surveys are a baseline of stakeholders' views and concerns and provide useful information for developing targeted communication programs. The results led to an increased emphasis on outreach activities, such as the Speakers Bureau and Ambassador program. The Ambassador program offers employees the opportunity to join with their neighbors for the benefit of their community.

BNL also instituted an Envoy program in which selected employees act as informal liaisons and bring Laboratory issues to the attention of their community groups and the groups' issues to the attention of the Laboratory.

Many people visit or participate in education, museum and tour programs at BNL and develop a more positive attitude and become more informed about BNL. In addition, specific groups participate in individual programs. In FY99, the Laboratory will host more than 12,000 students who participate in demonstrations and lectures. About 1,500 of these students will participate in science contests or similar activities. An estimated 750 elementary, high school and college teachers will accompany these students, and about 50 will take part in BNL's for-credit or in-service courses. Our science education programs will reach 7,500 students in their classrooms and another 650 students through library programs. About 3,200 people will visit the

Laboratory for Summer Sunday Programs, and another 1,600 parents will accompany their children to on-site student activities.

The Communications & Trust Advisory Panel (CTAP) ensures that BNL's Community Involvement & Public Affairs activities are comparable to the best quality programs around the country. Composed of recognized leaders in public relations, community involvement, and academia, CTAP will evaluate the Laboratory's employee and public communications and procedures with a view toward ongoing improvement and enhancement.

Major, positive communication actions will track closely with the program directions and scientific initiatives discussed in the Institutional Plan. BNL communications also will focus on enhancing the Laboratory's scientific reputation and demonstrating close alignment with the Department of Energy's Strategic Mission: Science & Technology, Energy Resources, National Security, and Environmental Quality.

7.4 Human Resources and Diversity

Our Human Resources goal is to continue to support performance-based management and contribute to achieving the Laboratory's Critical Outcomes. To support performance-based management, we have taken the following steps:

- Conducted an organizational survey in June 1998 on the quality of work-life at the Laboratory,
- Established and executed the documentation of Roles, Responsibilities, Accountabilities, and Authorities (R2A2s) for all employees, and
- Established a new process of management-performance evaluation that includes goal planning tied to the critical outcomes and performance objectives.

While the most positive response from the survey indicated that employees are satisfied with their benefits, other findings revealed areas in which the Laboratory scored lower than the national norms for R&D organizations. Four employee volunteer-focus groups were convened to review the four areas that required the most attention: Diversity, Employee Involvement, Training and Development, and Communication. The groups presented their findings and recommendations to senior management. A plan to address these findings will be developed during FY99-00.

The R2A2s are the work-assignment mechanism of the Laboratory, and delineate the authority granted to individuals commensurate with their responsibility. R2A2s will be refined and integrated in Human Resource systems such as hiring requisitions, training assessments, performance appraisals, and job evaluations.

The new process of management-performance evaluation that includes goals tied to Critical Outcomes and Performance Objectives is a key element of Performance Based Management. The summary performance level is based on achieving individual goals and incorporates an evaluation of the employee's performance with respect to the responsibilities in their R2A2.

Human Resources plans to pursue several objectives integrated with those of other organizations to meet the Laboratory's critical outcomes. In basic science and technology we developed and implemented programs to promote the hiring of women and underrepresented minorities as post-doctoral Research Associates and Scientific Staff. This $1.4 M Diversity Initiative will subsidize half of the employee's salary for the hiring organization for two years. Over the next six years, we will support eight Research associate and five junior Scientific Staff positions. This initiative will promote long term change in the Laboratory's current ethnic and gender profile as depicted in Table 30 of Appendix D. Over the past 10 years there has been a slight growth in the representation of women and a decrease in the representation of black males.

In accord with the Laboratory's Strategic Plan for Diversity, all level 1 and 2 managers will be required to set goals in the Diversity area and will be accountable for achieving those goals. Additionally, all supervisors are accountable for their performance in this area.

The Laboratory has intensified efforts to recruit women and underrepresented minorities by identifying new sources of candidates. These efforts include an expanded use of web page advertising targeting underrepresented groups and increased participation at job fairs sponsored by organizations such as the National Society of Black Engineers and the Society of Hispanic Engineers. Part of the $1.4 M Diversity initiative will be allocated to increase our contacts with Hispanic and Native American institutions as well as historically black colleges and universities.

Through the Human Resources program, the Laboratory helps to establish trust with the outside community through blood drives and a computer-training course for adults from the community, using Laboratory volunteers as instructors. We are planning a training program for adults with disabilities to learn the skills of a laboratory assistant. These activities are visible indications of the Laboratory's value and responsibility to the community.

The Standards Based Management System (SBMS) includes a Human Resources Management System Description related to HR functions and services. Several HR manuals for employees and supervisors are accessible through SBMS and will be translated into subject areas as the system develops.

Human Resources support the Critical Outcome in environmental stewardship. Responsibilities for environmental matters are a part of the R2A2s for all employees and supervisors; they are instrumental in addressing the results of environmental audits and satisfying the requirements of the Laboratory's Environmental Management System.

Human Resources plays a lead role in several efforts to enhance leadership by developing a succession-planning process for senior management positions, enhancing the diversity of the Laboratory's management staff, initiating a 360-degree feedback evaluation for top managers, and developing hiring criteria for Laboratory managers.

We also are working with DOE's staff to review and evaluate the value of employee benefits and the effectiveness of the compensation system. The resulting recommendations will form the basis for future improvements. While the survey results indicated that employees'

attitudes towards compensation was comparable to other R&D organizations, we continue to seek ways to improve the compensation program.

7.5 Information Management

7.5.1 Information Technology

In Information Technology (IT) our goal is to re-engineer Information Technology services at Brookhaven National Laboratory, and to redirect IT resources to fully support the Laboratory's goals and Critical Outcomes. The overall approach will generate efficiencies in the administrative computing and communications infrastructure, resulting in an increased ability to focus resources on building a scientific computing infrastructure in support of the Laboratory's core programs

The restructuring of IT across the site includes the following ongoing initiatives:

- Establish an IT Leadership Council to be the vehicle for functional leadership of Information Technology at the Laboratory, disseminating "best practices" comparable to those in industry, setting the IT mission, vision and core values and establishing the planning process for developing the IT Strategic Plan.
- Create an IT Strategic Plan driven by the goals and objectives of the major scientific and support departments.
- Improve the Administrative Computing and Communication Infrastructure, including the following actions:
  - Standardize the desktop, including hardware and software to facilitate information sharing and exchange.
  - Establish a central e-mail (Exchange) server.
  - Establish a remote management framework using technologies such as Systems Management Server for efficient asset management, cost reduction and increased responsiveness to problem-solving.
  - Consolidate Laboratory-wide server support by co-locating department/division servers in the BNL Computing Facility, and determining whether multiple small servers with comparable functions can be consolidated for improvements in administration.
  - Assess the Laboratory's computer security status and develop a plan to provide a computing and communications environment that is secure, yet allows for the collaborative working model that is essential for fostering scientific research. This will include completition of a lab-wide vulnerability assessment, procurement and installation of security tools, implementation policies and processes consistent with recommendations from the vulnerability assessment, completition of the plan for upgrading the physical security to effectively protect the Laboratory's network backbone, development of processes to exchange information with other institutions to guarantee that security measures and collaborative requirements can coexis, and rreorganization of ITD to more effectively support the Security function. This includes developing a team to focus on network security, insuring that their training and knowledge in this area remains current.

The Information Technology Division was reorganized in support of this new site-wide IT strategy and its services redefined to insure that they add value to Laboratory programs. In the implementation of the changes that will be taking place, ITD is investing heavily in its people and is focused on strengthening leadership in the process. Future emphasis will involve the following areas:

- Scientific Computing Support program - A section in ITD will be dedicated to supporting the scientific computing effort at the Laboratory, with particular emphasis on IT involvement at the project planning stage.
- Training - There will be increased emphasis on training within the Division, in both the technical and management areas.
- Sourcing Strategies – Sourcing strategies for all IT services will be continually reviewed. This includes the study of outsourcing as a solution.
- Manage by Fact – IT services will be continually reevaluated, to insure value-added for the user community. A metrics program will be adopted to measure efficiency, quality and responsiveness to customers. A benchmarking program will be put in place to objectively compare these services to industry's "best practices".

7.5.2 Business Information Management

Business Information Management is vital to effective scientific performance, and to efficient, cost-effective administrative functions. Our goal is to provide state-of-the-art computational resources that meet the needs of the research programs. Business Information Systems will develop programming, administrative architecture, security and applications architecture, application training, and archiving for major business systems.

The Financial Services Division (FSD) facilitates the implementation of several major new administrative information systems, starting with an integrated suite of financial-management software packages purchased from PeopleSoft, Inc. By mid FY2000, all existing applications, except Human Resources and Payroll, will be moved from the existing Hewlett-Packard mini-computers to a Windows NT operating system. Several other projects soon will benefit the BNL community. These include the completion of the Brookhaven Training Management System, a centralized Guest/Visitor Registration & Tracking System, streamlining of labor entries, reduction of paper reports, and electronic (check-less) payments.

We are replacing the accounting system with an "off-the-shelf" suite of integrated financial packages, and will modify business practices to match the products' features. The PeopleSoft financial applications are Y2K-compliant. Except for the Travel and the Job Cost & Reporting Systems, applications not replaced by PeopleSoft are Y2K-compliant.

7.5.3 Information Services

Our Information Services strategic goal is to achieve full electronic management of documentary information, from its initial generation to archival preservation. This will increase

the efficiency with which scientific and technical information is managed and maximize ease of access throughout its life cycle. The Laboratory will be positioned to leverage its information by using sophisticated search-engines, electronic information management systems, and emerging technologies to ensure its full utilization in support of the scientific research mission.

Our near-term strategies include the electronic transmittal of full-text documents, building and maintaining document- and image- repositories, providing electronic publishing, library, and records management services, and making information accessible to users from their desk tops on the world-wide web. All BNL's research organizations have begun electronic transmittal of scientific and technical publications. The electronic workflow will be expanded to include the Office of Technology Transfer, which reviews BNL scientific and technical publications for intellectual property.

In consultation with the Research Library Advisory Committee, the Information Services Division (ISD) developed a plan to identify opportunities for cost savings on subscriptions by acquiring electronic journals. We are engaged in partnerships with other DOE contractors, DOE's Office of Scientific and Technical Information, other libraries, and academic professional associations to negotiate discount pricing and consortium purchase-agreements with publishers and distributors of serial publications.

We provide electronic publishing support using Web technology to produce scientific- and administrative-publications and to enable electronic submission of papers by researchers worldwide for scientific conferences such as the Particle Accelerator Conference, which will be hosted by BNL in 1999. This capability will be transferred to the host organization for next year's conference.

Our digital photo archive makes images accessible via the Intranet for on-line viewing and ordering of photographic prints. The digital archive and new digital video services facilitate the production of multi-media information products. The transition from traditional chemical photographic processing to digital operations was made possible through the DOE High Return on Investment Program that enabled us to consolidate operations and resulted in an 80% reduction of ISD photographic hazardous waste.

The Laboratory also plans to acquire two new systems, a Library System, to replace the present system, and a fully automated Records Management System. The new Library System will improve efficiency and enable researchers to locate more information from their desktops. The new Records Management System will provide greater capability for managing records than can be realized with the current Records Inventory database, and will facilitate our efforts to develop a vital records program.

7.6 Safeguards and Security

Safeguards and Security exists to support the basic scientific mission of DOE and the Laboratory, with the following objectives:

- To protect DOE's Special Nuclear Materials, Classified Matter and Property against theft, diversion, or destruction,

- To prevent the loss of information or sabotage of programs that could have significant financial impact, and
- To prevent radiological- or toxicological-sabotage that would endanger employees, the public, or the environment.

The Laboratory will achieve these objectives through programs such as Operations Security, Technical Surveillance Countermeasures, Classified Computer Security, Communications Security, Material Control & Accountability, Security Education and Awareness, Traffic Enforcement, Property Protection and On-Site Hazardous Materials Packaging, and Transportation Safety. We also implement preventive programs, such as property-protection access controls, site surveillance, community crime prevention, and security education and awareness.

BNL has a Counterintelligence Program Manager who is responsible for the overall counterintelligence program. We coordinate program activities through the DOE Brookhaven Group and the DOE Office of Counterintelligence, Washington, D.C. The Manager works closely with BNL's Safeguards and Security personnel and the Operations Security (OPSEC) Work Group, as well as other Federal agencies. The program covers many areas, including protection of information, foreign travel briefings and debriefings, host debriefings, and interactions with the foreign visits and assignments office. The Manager leads the Laboratory's effort to expand and update the list of sensitive technologies.

The Standards Based Management System (SBMS) allows site-wide access to information on safeguards and security policies, such as access controls, fraud, waste, abuse, corruption and other criminal offenses, classified information and security requirements, visits and assignments of foreign nationals, computer security, and contractor and subcontractor registration. The Security Manual, also available through SBMS, gives employees specific guidance on security matters and procedures.

Safeguards and Security staff interact with BNL’s departments and employees to establish guidelines, plans, and strategies to protect sensitive or classified information, export information, cooperative research and development agreements, protocol visits, and Work For Others. Vulnerability Assessments (VA) are done before a visit, such as the IAEA Inspection, where the VA will involve the Departments of Defense and Energy, as well as OPSEC and Counterintelligence personnel. BNL's Department of Advanced Technology (DAT) conducts research and development and provides technical support in the areas of nonproliferation and national security. Members of DAT interact with Safeguards and Security personnel through the Operations Security Group and the Classification Advisory Group.

The Safeguards and Security Enhancement Plan is a long-range plan to ensure security is upgraded efficiently and cost-effectively. Subject-matter experts annually review the Plan to ensure that the necessary protective measures are planned systematically to identify and prioritize vulnerabilities. The Visitor Reception Center is an important long-range project for Safeguards and Security. The project would provide a facility where visitors, vendors, contractors, new employees, and the public could obtain information about the Laboratory, receive safety and other training, housing assignments, badging and vehicle registration.

The DOE Brookhaven Group and the DOE Chicago Operations Office annually review and approve the Safeguards and Security Plan (SSP). The SSP, a classified document, provides a blueprint for a successful safeguards and security program at BNL. In conjunction with the SSP, the Safeguards and Security Management System Description documents this is managed at BNL.

7.7 Site and Facilities

The BNL site is approximately 5,320 acres, and about 30% of the total area is developed. There are approximately 400 buildings (Table 6) in use with a total area of 393,000 square meters (4.2 million square feet) and a replacement value shown in Table 7. Many buildings date back to World War II or before. Most of the remaining buildings were constructed in the 1960s. The site is served by site-wide utility systems
that include electrical, steam, sanitary sewer, storm sewer, and potable water. In addition, there are limited distribution systems for chilled-water and compressed air.

Table 6 – BNL Building Area

Space Type	Quantity	Gross Area (Sq. Ft.)	Gross Area (Meters)
BNL BUILDINGS	402	4,232,134	393,167
LEASED SPACE	1	1,000	93
PORTABLE STRUCTURES	379	117,437	10,910
TOTAL	**782**	**4,351,571**	**404,296**

Table 7 – Site Replacement Value

Facility Type	Value (Million $)
Buildings	3,236
Portable Structures	4
OSF	592
Total	**3,832**

7.7.1 Situation and Trends

Buildings: Approximately 67% of BNL's building space is at least 30 years old, with 39% over 50-year-old WW II construction. (Figure 12). The costs of maintenance, repair, and capital renewal are high, and the buildings are small and dispersed across the site. R&D space has risen from 72% in FY96 to 79% in FY99. This is attributable to the RHIC project that added significant R&D space with little associated support space. Over the past five years there has been a small rise in the total square footage due primarily to RHIC related construction and an addition to the Department of Applied Science building, 815. During this same period, the Laboratory undertook several intense efforts to measure each building, develop accurate key plans and identify every structure as either a building or portable structure. The reporting of

several assets was reconfigured to align more closely with the actual use of the facility. These simultaneous changes make it difficult to baseline the data, and there is therefore, no clear trend indicated at this time.

Since there is no clear definition based on the functional aspect of portable structures, BNL does not segregate trailers from other portable structures. All portable structures are included in the space charge program. This has prompted the removal of over 120 portable structures from the site. In addition, for the last 5 years a policy has been effect that requires approval of the Assistant Laboratory Director for Facilities and Operations for the purchase or lease of any trailer.

One existing lease has been in effect since 1996 for a 1000 sq. ft apartment for staff involved in a program in North Carolina. The number of contaminated surplus facilities has not changed since 1994 while the number of non-contaminated surplus facilities has increased from 3 to 7 since 1996. We expect 2 to 3 additional facilities may be surplused over the next two years.

Budget constraints create extended deferrals of capital renewal and replacement projects and annual maintenance. Maintenance and energy costs for the older, wood-frame buildings are higher than for structures that are considered permanent. Many older wood-construction facilities do not meet current structural standards for wind and seismic loads, and also do not comply with the current Life Safety Code Standards (Table 8, Figures 13 and 14). Retrofitting older facilities to comply with current ES&H standards is extremely costly. Consequently, through our planning efforts, we identify those facilities for which further investment will yield an economic life-extension and those facilities where demolition is the best course of action. We are working on criteria for a formal method to assess the future of these buildings; these criteria will be factored into the Master Planning process.

Figure 12 - Age of Available Building Space

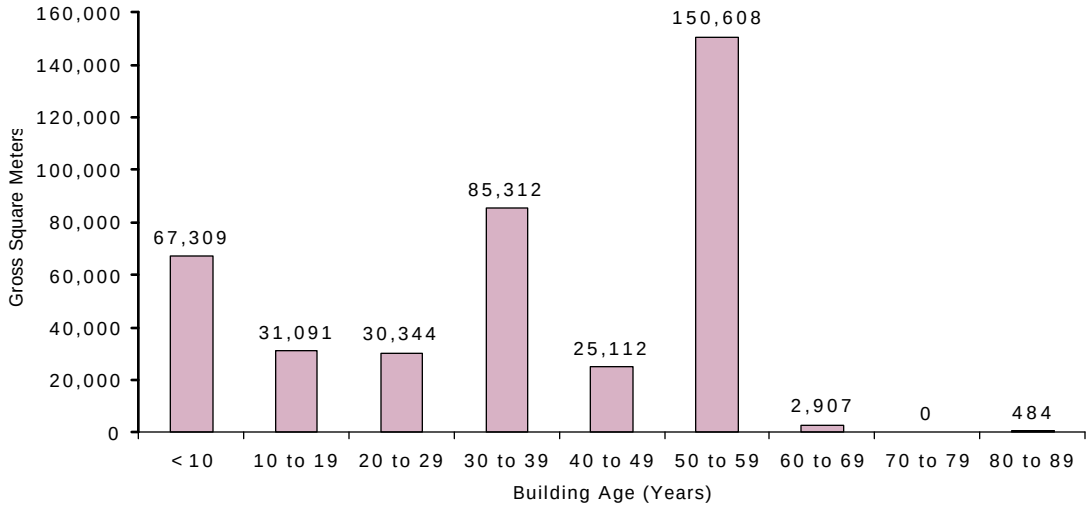


Table 8 – BNL Building Area Condition

	ADEQUATE	MINOR REHAB	MAJOR REHAB	REPLACE	SURPLUS	TOTAL
Admin	9,115	66,611	2,563	0	0	78,289
Housing	16,745	2,906	0	498	0	20,149
Storage	2,991	8,859	4,623	2,889	2,316	21,678
Production	7,034	177	0	0	500	7,711
Service	4,841	10,952	2,631	4,896	1,319	24,639
R&D	9,866	94,575	11,571	2,561	4,990	123,563
Reactor & Accelerators	60,852	41,582	10,943	0	3,761	117,138
Total	**111,444**	**225,662**	**32,331**	**10,844**	**12,886**	**393,167**

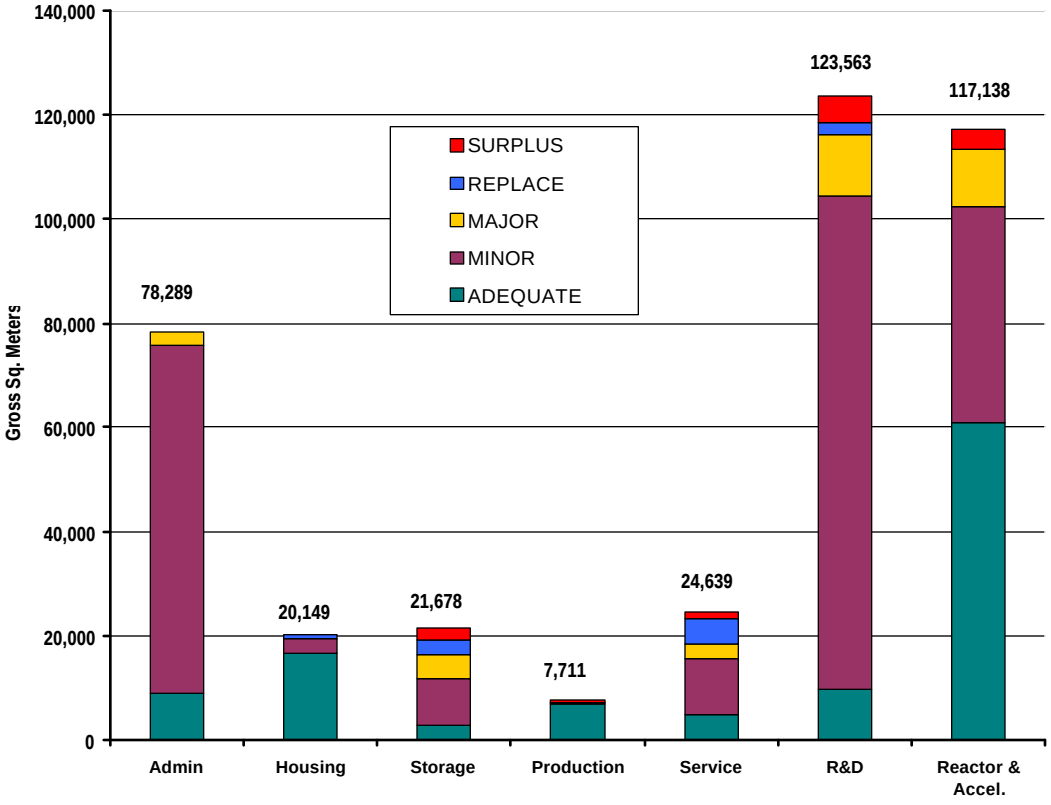
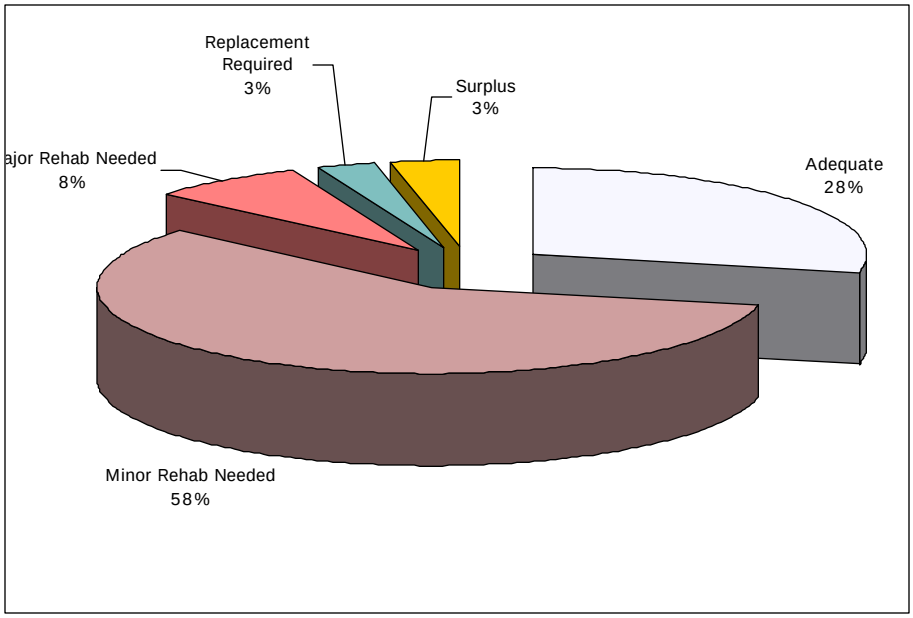


Figure 13 - Building Condition

Figure 14 - Building Condition - Percent of Total Area



We have a limited capacity for preventive and breakdown maintenance due to the downsizing of the maintenance staff and continued growth of the site. Roofing systems are failing or have failed and require replacement. This condition is exacerbated by the failure of second-generation roofs on many older facilities. Only 25% of the roofs requiring replacement have been replaced; most re-roofing was accomplished under the 1993 Multi-program Energy Laboratory Facility Support (MEL/FS) project. Since then, additional failures have further increased the backlog. Prolonged water infiltration from roof leaks may lead to equipment damage, structural damage, and the shutdown of facilities for extensive repairs, or require abandonment or replacement.

Utilities: Site-wide utility systems have been a high priority for maintenance and capital renewal over the years, and we received good support from the Multi-Program Energy Research Facilities Support (MEL/FS) program. In addition to ensuring operational continuity, properly maintained and updated utility systems are essential to safe, environmentally benign operations.

The Central Steam Plant is highly reliable as a result of two fairly new boilers. However, upgrades are needed to an existing, 35-year-old boiler and the building's enclosure. Our recent conversion to dual fuel (fuel oil/natural gas) should ensure that the Laboratory complies with emerging environmental regulations. Underground distribution lines, many dating back 50 years, will soon need replacing. An aerial infrared thermographic survey is being performed to locate those sections of the lines most in need of replacement.

With the commissioning of RHIC, the Laboratory’s peak electrical demand will grow by about 30%. Additional capacity will be needed, and we are partially addressing this through power-factor correction. Transformer capacity is adequate; however, future additions will be necessary to re-establish firm capacity. The primary 13.8 kV distribution feeders are aging;

fifteen are over 40 years old. Failures of the feeders continue to be the most prevalent cause of unplanned facility shutdowns.

BNL continues to enjoy favorable electric rates under a contract with the New York State Power Authority (NYPA). Electric deregulation has been slow to develop in New York and will be even slower on Long Island due to the acquisition of the Long Island Lighting Company (LILCO) by the Long Island Power Authority (LIPA). Currently, BNL is evaluating strategies for buying electrical power after the NYPA contract expires in July 2000.

The outfall from the Sewage Treatment Plant discharges to the Peconic River, a New York State Wild and Scenic River. Recent upgrades to the plant provided tertiary treatment and ultraviolet disinfection. A water conservation program, combined with a campaign to eliminate cooling-water discharges, decreased the volume of sewage so that permit conditions on biological oxygen-demand removal now are routinely met. The Sanitary III project will replace 9,300 linear feet of sanitary sewer lines and add 7,200 linear feet of new lines that will help eliminate septic tanks and address the concerns of Suffolk County.

Recent improvements to the Chilled Water Plant include chilled water storage capability that stores chilled water during periods of low electrical use so that the capacity is available during peak periods. This provides about 20,000 ton hours of additional cooling capacity and reduces peak electrical demand on site by about 1 MW.

The potable water system was improved by installing new mains, carbon filtration, air-stripping of volatile organics, repairs to the water towers, and improvements to the Water Treatment Plant. Recent inspections suggest that the 300,000 gallon elevated water storage tanks will require considerable investment in the near future.

7.7.2 Resource Trends

The Laboratory historically relied on General Plan Projects (GPP) for small, urgent project needs. BNL developed a process for assigning priorities to ES&H, Infrastructure and Program Support projects and is testing the process for the FY 1999 program. Currently, the bulk of high-priority needs lie with ES&H. These projects represent 84% of the value, and 65% of the projects of the non-programmatic backlog. While the size of the GPP project increased to $5 million and opportunities exist to make significant improvements and realize cost-savings by replacing and consolidating buildings, it is unlikely that BNL can use this increased flexibility, due to the backlog of projects. In FY 98, several reprogramming actions resulted in a one-time increment of $2.5 million in GPP funding. In FY 99, $2 million of GPE (General Purpose Equipment) was reprogrammed to GPP.

There are several adverse trends that indicate a greater demand on the Laboratory's funds for operating and capital construction to address all moderate and high-risk infrastructure, ES&H, and program needs.

Figure 15 shows the trend in GPP funding and purchasing power. The trend is downward for GPP, despite the increase in the Laboratory's assets over the same period; actual purchasing

power, which factors in inflation and indirect costs, shows a sharp decline. With 1985 as the base year, each GPP dollar is now worth $0.53.

The backlog of projects to maintain the physical plant in acceptable condition continues to grow. Beginning in FY95 pressure to reduce overhead funded activities and increase spending on ES&H activities resulted in a downward trend in maintenance spending. In FY99 the trend began to reverse and maintenance spending is approaching the FY94 level. However, during this time additional facilities were added to the inventory, existing facilities continue to age, and the maintenance backlog has grown.

Much of the infrastructure is the over 50 years old and beyond its useful life. The increased age of facilities, declining purchasing power, flat or declining budgets, and increased emphasis on ES&H contributed to a doubling of the GPP backlog over the past 5 years (Figure 16). During the same period the GPP funds received has remained relatively flat, except for some reprogramming efforts.

Figures 17 and 18 show the upward trend in spending on ES&H projects as a percent of available funds, demonstrating the Laboratory's increased emphasis on addressing ES&H issues. However, this also shows a decrease in funds available to address infrastructure concerns.

The General-Purpose Equipment (GPE) budget that supports equipment needs for BNL's operations averages approximately $4 million annually. To cover a significant shortfall and meet other needs, equipment expenditures were reduced by 50% in FY 98 and FY 99, deferring $2 million in capital equipment needs each year.

Figure 15 - GPP Purchasing Trend

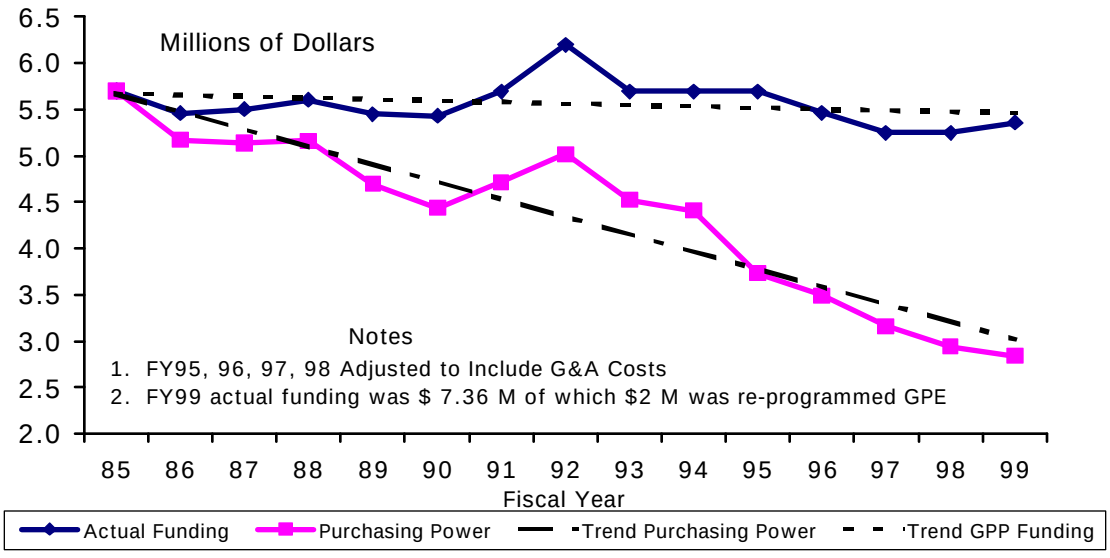


Figure 16 -GPP Backlog

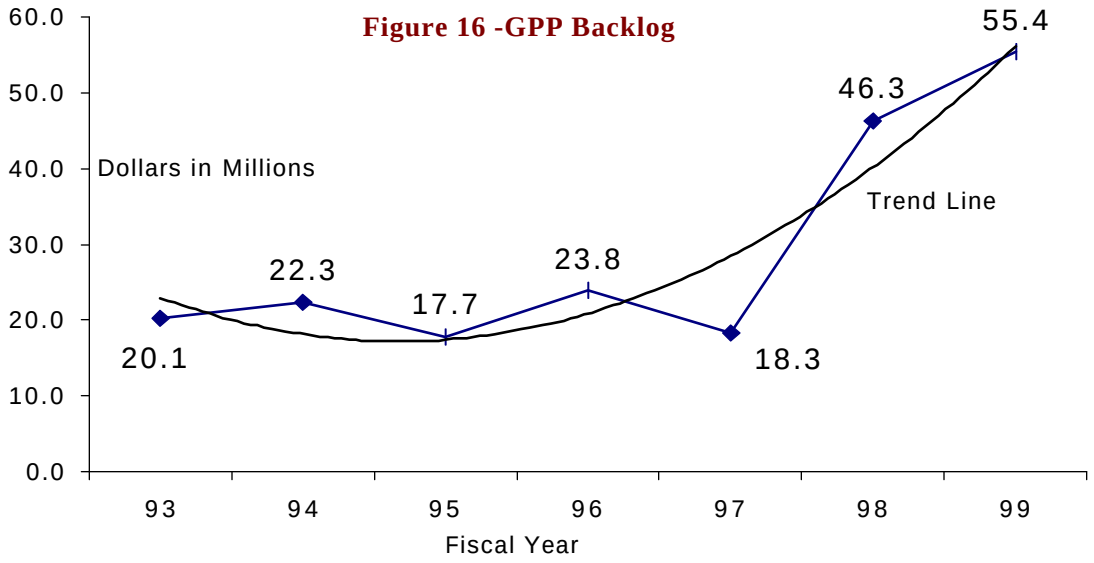


Figure 17 - GPP Percent Spending for ES&H

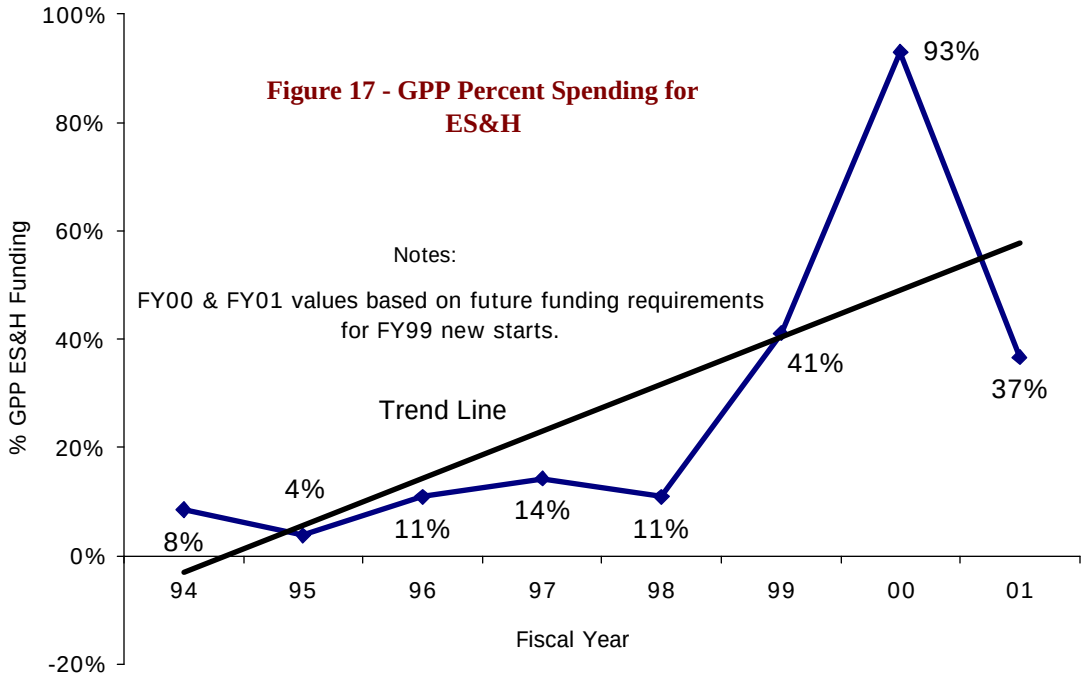
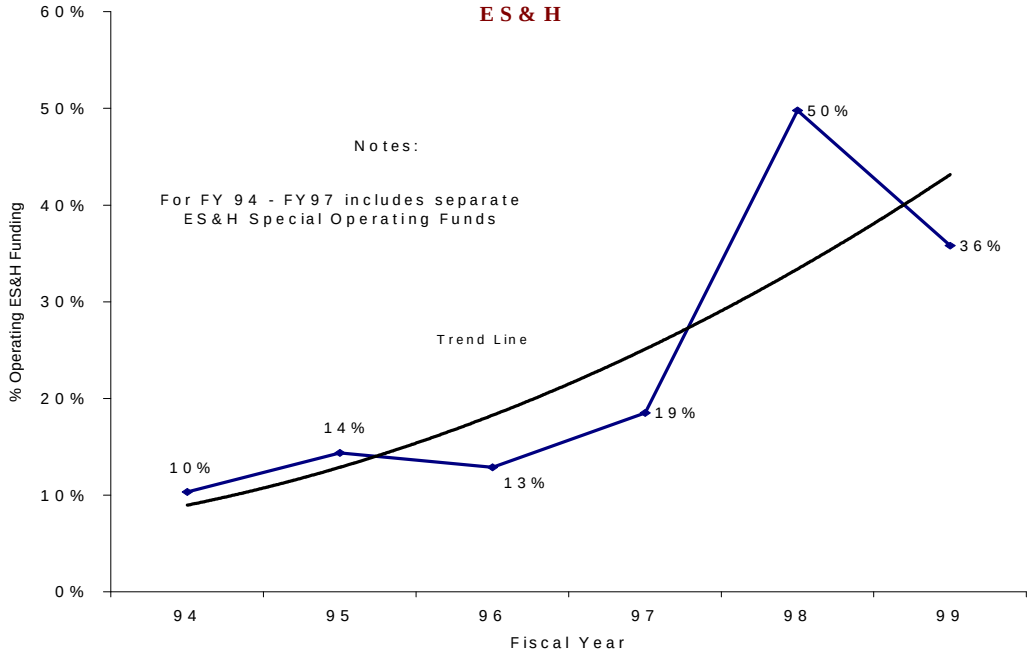


Figure 18 - Operating Percent Spending on ES&H



BNL will continue to use the funds available through the Multi-program Energy Laboratory/ Facility Support (MEL/FS) Program to upgrade environment, safety, and health (ES&H) protection, improve utility systems, increase efficiency through consolidation, and also replace, mothball, or demolish aged inefficient facilities to reduce operating costs. The anticipated MEL/FS line item requirements from FY 99 to FY 04 are approximately $79.4 Million. Based on a ten-year average funding level of $5.5 million, a $46.4 million shortfall is expected by 2004.

We will continue to evaluate the condition of our permanent multi-program facilities and will propose line item projects to rectify deficiencies and bring them up to current standards. Such projects include replacement space that will consolidate functions and eliminate sub-standard space.

Various assessments identified the need for new facilities. In 1999, BNL will undertake a site study to develop a new Master Plan that will identify facilities that should be replaced. With the commissioning of RHIC, facilities will be needed to accommodate approximately 250 scientific users. We are developing strategies to address these concerns in the near-term, but longer-term solutions will be needed, such as the proposed RHIC Science Center.

7.7.3 Facilities Plans and Options

The low funding levels challenge the Laboratory's ability to significantly improve infrastructure. At the same time, operating costs have increased, as the maintenance of aged

buildings and utility systems becomes more difficult and expensive. The consolidation of staff accommodations will be delayed; both in the scientific and support areas and the thrust of future initiatives will be affected by the Laboratory's ability to provide a working environment consistent with the quality personnel it must attract.

We have developed strategies to meet the challenges of maintaining old, deteriorated wood-frame structures and aged utility systems in a period of static or declining budgets.

- Establish a system of prioritizing projects that involves senior management, to maximize the use of project funds for the Laboratory's strategic goals. The top priority infrastructure projects are the following:
- FY 1999 Line Item to replace sewer lines and to improve the Sanitary Sewer system.
- FY 2001 Line Item to replace failed roofing systems.
- FY 2001 Line Item to replace damaged underground feeders and malfunctioning circuit breaker mechanisms.
- FY 2002 Line item to replace underground steam distribution lines.
- Evaluate options for electrical power, including competitive procurement, and extending or renegotiating the NYPA contract.
- Use Planning Teams to identify issues related to buildings and utilities and communicate them to management, with proposed actions to identify capital- and operating-funded projects and their potential impacts. A near-term goal is to establish criteria to determine whether or not a facility should continue to receive maintenance and capital investment.
- Develop the space-charging program further to identify space that is uneconomical to maintain and can be demolished or mothballed, resulting in operational savings.
- Determine the feasibility of and method for securing and using third-party funds to construct new space. As part of the development of a new Site Master Plan, a feasibility study is underway to determine alternative financing approaches to meet near-term and long- term facility needs. With the continuing decline in federal infrastructure budgets, the prospect of securing capital renewal funds through the MEL/FS and GPP programs is remote. These program remain taxed by high priority ES&H needs, and third party financing may be the only alternative for achieving the large scale replacement of infrastructure needed to sustain the Laboratory. are dominated by high priority ESH&H needs. Third party financing may be the only viable alternative to achieve the large-scale replacement of infrastructure needed to sustain BNL. The study will document current regulations governing the use of third party funds and explore options pursued by other government agencies.
- Develop plans to consolidate workspaces and personnel in more acceptable areas and vacate, mothball or demolish unsatisfactory wood buildings.

The Laboratory used the revised prioritization process for Environment, Safety and Health and Infrastructure project to establish the projects proposed for this planning period. This process helps balance ES&H and infrastructure needs, develop long-term ES&H improvement strategies to decrease future liabilities, and improve the overall infrastructure of the Laboratory.

The projects proposed for FY 2000 through FY 2004 represent the application of strategies that include compliance with regulations, worker protection, proactive protection of the environment, preservation of assets, and reliability of utilities. In FY 1999, the Laboratory began the third and potentially final phase to improve the sanitary sewer system, and started a phased program to upgrade the electrical distribution system. The sanitary system will be expanded to remove septic systems, and lines that are a potential source of contamination of the groundwater will be replaced or lined. Additional improvements will be made at the Sewerage Treatment Plant to comply with groundwater regulations and improve performance. The upgrades to the electrical system will increase the system's reliability by reducing the number and length of unplanned outages to the Laboratory's research facilities.

In FY 2001, we are proposing a significant Ground and Surface Water Protection project that will move the Laboratory to a more proactive position in protecting ground- and surface-water. This project will close inactive wells, modify storage facilities to prevent contaminated run-off, and remove underground tanks and lines.

An immediate concern is the continued growth of the backlog for roof replacement. In FY 2001, we propose a project to replace the roofing systems of 20 buildings. An additional phase is planned for FY 2004 to further decease the growing backlog. In FY 2001, we also propose completing the second phase of upgrades to the electrical distribution system. It will improve system reliability by replacing aged feeders and switchgear.

In FY 2002, we propose starting a project to rehabilitate underground steam lines and extend the life of the oldest boiler at the steam facility. This project continues BNL's efforts to meet code and operational safety requirements.

Other projects proposed for this planning period (Appendix D) include modifications for Life Safety Codes, replacement of aging facilities occupied by the Department of Advanced Technology, and replacement of Halon fire protection systems. The proposed upgrades to facilities and utilities include replacing more roofs, extending our Chilled Water capabilities, and installing fiber optics to improve the Laboratory's network capabilities.

Inadequate funding for the General Purpose Facilities sub-program is continuing the cycle of high operating and maintenance costs rather than securing prudent reductions through increased investment in new facilities. The Laboratory is concerned about the inability of the MEL/FS Program to address ES&H needs while dealing with infrastructure needs.

As new programmatic initiatives such as RHIC are completed, the Laboratory will experience a large influx of users, collaborators, and visitors, increasing the demand for suitable workspace and support services. This will be offset, but only in part, by reductions in some programs and associated support staff. Several projects are needed to consolidate major scientific departments and support functions currently dispersed throughout the site, including Users' facilities for RHIC and the NSLS, and a facility for support organizations. All are consistent with the efforts to improve the Laboratory's research environment, decrease future ES&H liabilities, and eliminate older wooden structures constructed over 50 years ago as temporary facilities.

7.7.3 Assets Management

The Laboratory maintains comprehensive Assets Management Programs encompassing all use, control and disposal of assets in a cost-effective, efficient manner.

Real Property: Real property records are maintained in the DOE's Facility Information Management System (FIMS) and reconciled with the Laboratory's financial records. During field surveys as part of the Facility Inspection Program, FIMS records and building key plans are reviewed for accuracy. Information on building conditions, deficiency lists, and requests for upgrades are reviewed to assess facility life cycle and to identify those assets for which further capital investment is warranted or for which demolition is preferable. For assets the Laboratory seeks to demolish, either the DOE's Office of Science (SC) landlord funds or the DOE's Environmental Management funds are requested.

Personal Property: The Laboratory uses an active Walk-Through Program to ensure that all appropriate equipment is identified and properly controlled and to monitor and identify any idle or surplus materials. The Laboratory also uses a site inspection program to monitor the accumulation of materials. These programs, coupled with the Waste Minimization Program, provide the Laboratory with the ability to quickly and efficiently dispose of surplus assets, consistent with the appropriate Federal and DOE Property Management Regulations.

Space Management: In FY98 BNL began a charge-back program that charges departments and divisions for actual use of space. Occupied space and rates are adjusted each quarter. Each space is classified and assigned general rate categories shown in Table 9.

Table 9 - Space Charge Rate Categories

Type of Space	Description
0	Common Space (corridors, bathrooms, electrical and mechanical space associated with operations of the facility.)
1	Normally unoccupied space, such as • Programmatic equipment support spaces, electrical and mechanical space associated with the operation of the program • Storage spaces
2	Normally occupied, space such as • Industrial space, such as machine shops, technical and craft shop areas • Non-laboratory high bay industrial areas, such as manufacturing, testing and assembly areas • Commercial space, such as the Research Library
3	Normally occupied space such as • Offices • Laboratories • Conference Rooms and Department/Division libraries.

Inactive Surplus Facilities: Table 10 summarizes facilities ready for demolition if funding is available either through the Landlord program, the DOE Office of Science (SC), or through transfer to the DOE's Office of Environmental Management

Table 10 – Inactive Surplus Facilities Plan

Building Name	FIMS Asset Number	Responsible DOE Program	Program for Demolition
Well #1	0093	Landlord	(5)
Well #2	0168	Landlord	(5)
Sheet Metal Shop	0202	Landlord	(5)
Storage	0208(1)	Landlord	(5)
Incinerator	0428	Landlord	(5)
Chemical Storage	0444	EM	EM
Administration	0445(2)	EM	EM
Waste Compaction	0446	EM	EM
Storage Rigging	0447	EM	EM
Nuclear Waste Storage	0448	EM	EM
Radioactive Waste Storage	0650A(3)	EM	(5)
Brookhaven Graphite Reactor	0701/702	(4)	(6)
Instrument House	0708	(4)	(6)
Canal House	0709	(4)	(6)
Former 7 Foot Bubble Chamber	0960	Landlord	(5)

(1) Used for temporary storage.
(2) Used for temporary support space for D&D work at the former Waste Management Facility
(3) Used for temporary storage of waste. EM is responsible for D&D and return to the Landlord
(4) Responsibility is defined by a DOE Office of Science and Office of Environmental Management Letter of Understanding.
(5) The Laboratory G&A is responsible for demolition. An ADS was developed for demolition, however funding is not likely in the near future because of the low risk.
(6) Final plan has not been developed.

7.7.4 Energy Management

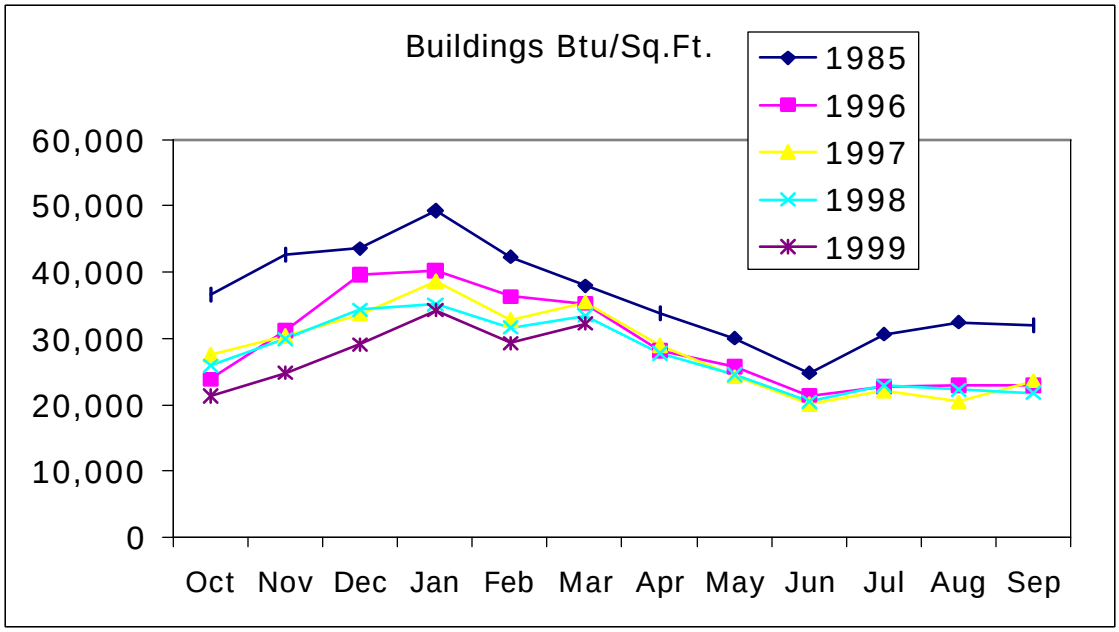
Brookhaven annually spends over $20 million for energy. To deal with this large energy expenditure, BNL's Energy Management Group develops, implements, and coordinates an Energy Management Plan, leads BNL's effort to meet DOE's energy reduction-goals:

- Demonstrate continuous cost-effective improvement toward reducing building energy use per square foot.
- Demonstrate continuous cost-effective improvement on an annual basis toward increasing energy efficiency in industrial facilities, and BSA's performance criteria to realize a decline in energy use.

Energy management initiatives have been very successful at BNL, as demonstrated by measured reductions in energy use (Figure 18). The site building energy use per square foot for FY 1998 was 24% less than in 1985, well ahead of the DOE's goal of a 20% reduction by FY 2000; we saved $2.3 M when compared to 1985.

The Laboratory also saved over $7.6 million in 1998 by using low-cost electric power from the New York Power Authority, bringing the total savings since 1981 to over $125 million.

Figure 19 - Annual Energy Consumption



8.0 Resource Projections

The only initiatives included in the projections for FY 2001 and beyond are the Cyclotron Isotope Research Center, and the RHIC Science Center.

Table 11 - LABORATORY FUNDING SUMMARY
($ IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
DOE EFFORT	261.2	296.7	290.8	302.7	304.8	304.8	304.8
WORK FOR OTHER THAN DOE	40.7	47.4	45.9	46.4	42.4	45.5	45.5
TOTAL OPERATING	301.9	344.1	336.7	349.1	347.2	350.3	350.3
CAPITAL EQUIPMENT	26.0	25.8	32.6	32.7	33.8	32.9	32.9
PROGRAM CONSTRUCTION(a)	63.3	35.7	49.2	76.3	85.8	79.0	52.4
GENERAL PURPOSE EQUIPMENT(GPE)	1.8	2.0	4.0	5.4	5.4	5.4	5.4
GENERAL PLANT PROJECTS(GPP)	8.3	7.4	5.4	13.0	11.8	11.8	11.8
TOTAL LABORATORY FUNDING	**401.3**	**415.0**	**427.9**	**476.5**	**484.0**	**479.4**	**452.8**

(a) Includes Spallation Neutron Source Construction
* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 12 - LABORATORY PERSONNEL SUMMARY
(PERSONNEL IN FTE)

	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
DIRECT							
DOE EFFORT	1463	1371	1254	1309	1336	1328	1316
WORK FOR OTHER THAN DOE	212	240	280	279	289	282	218
TOTAL DIRECT	1675	1611	1534	1588	1625	1610	1534
TOTAL ORGANIZATIONAL BURDEN	190	165	151	161	161	161	161
LABORATORY DIRECTED R&D	18	26	38	45	45	45	45
TOTAL MATERIAL BURDEN	82	85	91	94	94	94	94
DISTRIBUTED/ALLOCATED SERVICES	547	597	553	555	555	555	555
TOTAL INDIRECT	**545**	**531**	**590**	**592**	**592**	**592**	**592**
TOTAL LABORATORY PERSONNEL	**3057**	**3015**	**2957**	**3035**	**3072**	**3057**	**2981**

Table 13 - FUNDING BY ASSISTANT SECRETARIAL OFFICE ($ IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
DEPARTMENT OF ENERGY PROGRAMS							
DIRECTOR, OFFICE OF SCIENCE							
OPERATING	204.5	237.3	226.7	237.4	238.9	238.9	238.9
INVENTORIES	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAPITAL EQUIPMENT	24.5	25.6	32.4	32.2	32.4	32.4	32.4
GENERAL PURPOSE EQUIPMENT)	1.8	2.0	4.0	5.4	5.4	5.4	5.4
GENERAL PLANT PROJECTS	8.3	7.4	5.4	13.0	11.8	11.8	11.8
CONSTRUCTION	63.3	20.7	11.0	20.3	31.3	49.0	44.2
TOTAL	**302.4**	**293.0**	**279.5**	**308.3**	**319.8**	**337.5**	**332.7**
A/S CONSERVATION & RENEWABLE ENERGY							
OPERATING	4.3	2.7	3.7	4.1	4.1	4.1	4.1
CAPITAL EQUIPMENT	0.0	0.0	0.0	0.2	0.2	0.2	0.2
TOTAL	**4.3**	**2.7**	**3.7**	**4.3**	**4.3**	**4.3**	**4.3**
A/S ENVIRONMENT, SAFETY & HEALTH							
OPERATING	**3.1**	**0.7**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**
A/S NONPROLIF. AND NATIONAL SECURITY							
OPERATING	**16.7**	**21.9**	**22.3**	**22.4**	**22.4**	**22.4**	**22.4**
A/S, DEFENSE PROGRAMS							
OPERATING	**2.3**	**1.1**	**0.5**	**1.0**	**1.2**	**1.2**	**1.2**
A/S, ENVIRON. RESTORATION AND WASTE MGMT.							
OPERATING	26.8	29.8	32.4	32.0	32.0	32.0	32.0
CAPITAL EQUIPMENT	0.4	0.2	0.0	0.0	0.0	0.0	0.0
CONSTRUCTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	**27.2**	**30.0**	**32.4**	**32.0**	**32.0**	**32.0**	**32.0**
A/S, FOSSIL ENERGY							
OPERATING	1.0	0.6	0.8	1.1	1.2	1.2	1.2
CAPITAL EQUIPMENT	0.0	0.0	0.0	0.1	1.0	0.1	0.1
TOTAL	**1.0**	**0.6**	**0.8**	**1.2**	**2.2**	**1.3**	**1.3**
OFFICE OF NUCLEAR ENERGY							
OPERATING	**2.4**	**1.9**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**
OFFICE, SCIENCE EDUCATION/TECHNICAL INFO.							
OPERATING	**0.0**	**0.4**	**0.5**	**0.7**	**1.0**	**1.0**	**1.0**
OFFICE, POLICY PLANNING AND ANALYSIS							
OPERATING	**0.1**	**0.1**	**0.3**	**0.4**	**0.4**	**0.4**	**0.4**
TOTALS-DOE PROGRAMS							
OPERATING	261.2	296.7	290.8	302.7	304.8	304.8	304.8
INVENTORIES	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAPITAL EQUIPMENT	24.9	25.8	32.4	32.5	33.6	32.7	32.7
PROGRAM CONSTRUCTION	63.3	20.7	11.0	27.3	41.9	55.0	44.2
GENERAL PURPOSE EQUIPMENT	1.8	2.0	4.0	5.4	5.4	5.4	5.4
GENERAL PLANT PROJECTS	8.3	7.4	5.4	13.0	11.8	11.8	11.8
TOTAL	**359.5**	**352.6**	**343.6**	**380.9**	**397.5**	**409.7**	**398.9**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 14 - FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE (IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
DEPARTMENT OF ENERGY PROGRAMS							
DIRECTOR, OFFICE OF ENERGY RESEARCH							
AT-15 DEVELOPMENT & TECHNOLOGY							
OPERATING	0.1						
DIRECT PERSONNEL	1						
KA-02 FACILITY OPERATIONS							
OPERATING	51.9	35.5	5.4	8.0	8.0	8.0	8.0
CHANGES IN INVENTORIES							
CAPITAL EQUIPMENT	9.6	10.1	6.1	6.1	6.1	6.1	6.1
GENERAL PURPOSE EQUIPMENT	1.8	2.0					
GENERAL PLANT PROJECTS	6.3	7.4					
CONSTRUCTION (AIP)	0.9						
TOTAL FUNDING	**70.5**	**55.0**	**11.5**	**14.1**	**14.1**	**14.1**	**14.1**
DIRECT PERSONNEL	**258**	**196**	**79**	**79**	**79**	**79**	**79**
KA-04 RESEARCH AND TECHNOLOGY							
OPERATING	16.3	14.5	14.4	14.4	14.4	14.4	14.4
CAPITAL EQUIPMENT	0.0	0.0	6.8	8.0	8.0	8.0	8.0
TOTAL FUNDING	**16.3**	**14.5**	**21.2**	**22.4**	**22.4**	**22.4**	**22.4**
DIRECT PERSONNEL	**82**	**71**	**83**	**86**	**86**	**86**	**86**
KA HIGH ENERGY PHYSICS							
OPERATING	**68.2**	**50.0**	**19.8**	**22.4**	**22.4**	**22.4**	**22.4**
CHANGES IN INVENTORIES	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
CAPITAL EQUIPMENT	**9.6**	**10.1**	**12.9**	**14.1**	**14.1**	**14.1**	**14.1**
GENERAL PURPOSE EQUIPMENT	**1.8**	**2.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
GENERAL PLANT PROJECTS	**6.3**	**7.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
CONSTRUCTION (AIP)	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
TOTAL FUNDING	**86.8**	**69.5**	**32.7**	**36.5**	**36.5**	**36.5**	**36.5**
DIRECT PERSONNEL	**340**	**267**	**162**	**165**	**165**	**165**	**165**
KB-01 MEDIUM ENERGY PHYSICS							
OPERATING	3.0	2.8	2.8	2.8	2.8	2.8	2.8
CAPITAL EQUIPMENT	1.2	0.4	0.2	0.2	0.2	0.2	0.2
TOTAL FUNDING	**4.2**	**3.2**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**
DIRECT PERSONNEL	**16**	**16**	**17**	**17**	**17**	**17**	**17**
KB-02 HEAVY ION PHYSICS							
PHYSICS RESEARCH	6.9	6.9	5.1	5.4	5.4	5.4	5.4

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 14 - FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE (IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
FACILITY OPERATIONS							
AGS/TVDG OPERATIONS	5.0	5.8					
RHIC PRE-OPS/ INVENTORY	19.0	35.9					
RHIC COMPUTING	0.9	1.1					
RHIC OPERATIONS - EXPERIMENTAL		8.1	26.9	28.0	28.0	28.0	28.0
RHIC OPERATIONS - COLLIDER		23.8	73.9	78.0	78.0	78.0	78.0
TOTAL FACILITY OPERATIONS	**24.9**	**74.7**	**100.8**	**106.0**	**106.0**	**106.0**	**106.0**
TOTAL OPERATING	**31.8**	**81.6**	**105.9**	**111.4**	**111.4**	**111.4**	**111.4**
CAPITAL EQUIPMENT							
ADDITIONAL EQUIPMENT	6.3	10.0	7.1				
GENERAL PURPOSE EQUIPMENT			4.0	5.4	5.4	5.4	5.4
NEW EXPERIMENTS			4.0	4.2	4.2	4.2	4.2
OTHER PROGRAMMATIC	1.3	0.4	0.6	3.1	3.1	3.1	3.1
TOTAL CAPITAL	**7.6**	**10.4**	**15.7**	**12.7**	**12.7**	**12.7**	**12.7**
GENERAL PLANT PROJECTS	0.5		5.4	11.3	10.0	10.0	10.0
CONSTRUCTION (AIP)	1.3	1.3	2.6	9.6	11.0	11.0	11.0
CONSTRUCTION (RHIC) (a)	59.4	16.6					
RHIC SCIENCE CENTER (b)					1.6	10.0	8.2
TOTAL CONSTRUCTION	**61.2**	**17.9**	**8.0**	**20.9**	**22.6**	**31.0**	**29.2**
TOTAL FUNDING	**100.6**	**109.9**	**129.6**	**145.0**	**146.7**	**155.1**	**153.3**
DIRECT PERSONNEL	**461**	**490**	**449**	**450**	**450**	**450**	**450**
KB-03 NUCLEAR THEORY							
OPERATING	**1.1**	**1.0**	**1.1**	**1.0**	**1.0**	**1.0**	**1.0**
DIRECT PERSONNEL	**6**	**6**	**5**	**6**	**6**	**6**	**6**
KB-04 LOW ENERGY PHYSICS							
OPERATING	3.0	3.1	3.0	3.0	3.0	3.0	3.0
CAPITAL EQUIPMENT		0.1					
TOTAL FUNDING	**3.0**	**3.2**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**
DIRECT PERSONNEL	**13**	**13**	**14**	**14**	**14**	**14**	**14**
KB NUCLEAR PHYSICS							
OPERATING	**38.9**	**88.5**	**112.8**	**118.2**	**118.2**	**118.2**	**118.2**
CAPITAL EQUIPMENT	**8.8**	**10.9**	**15.9**	**12.9**	**12.9**	**12.9**	**12.9**
CONSTRUCTION							
GENERAL PLANT PROJECTS	**0.5**	**0.0**	**5.4**	**11.3**	**10.0**	**10.0**	**10.0**
CONSTRUCTION (AIP)	**1.3**	**1.3**	**2.6**	**9.6**	**11.0**	**11.0**	**11.0**
RHIC (a)	**59.4**	**16.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
RHIC SCIENCE CENTER (b)					**1.6**	**10.0**	**8.2**
TOTAL CONSTRUCTION	**61.2**	**17.9**	**8.0**	**20.9**	**22.6**	**31.0**	**29.2**
TOTAL FUNDING	**108.9**	**117.3**	**136.7**	**152.0**	**153.7**	**162.1**	**160.3**
DIRECT PERSONNEL	**496**	**525**	**485**	**487**	**487**	**487**	**487**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

(a) Funded
(b) Proposed

Table 14 - FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE (IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
KC-02 MATERIALS SCIENCES							
OPERATING (RESEARCH)	10.1	11.2	10.8	10.8	10.8	10.8	10.8
NSLS OPERATIONS	20.3	20.5	20.7	20.6	20.6	20.6	20.6
HFBR OPERATIONS	22.0	21.9	22.6	22.9	22.9	22.9	22.9
TOTAL OPERATING	52.4	53.6	54.1	54.3	54.3	54.3	54.3
CHANGES IN INVENTORIES							
CAPITAL EQUIPMENT	2.1	3.1	2.1	2.1	2.1	2.1	2.1
CONSTRUCTION							
GENERAL PLANT PROJECTS	1.5			0.9	1.0	1.0	1.0
CONSTRUCTION (ARAM)	1.1	1.5	1.5	4.4	4.0	4.0	4.0
TOTAL CONSTRUCTION	2.6	1.5	1.5	5.3	5.0	5.0	5.0
TOTAL FUNDING	**57.1**	**58.2**	**57.7**	**61.7**	**61.4**	**61.4**	**61.4**
DIRECT PERSONNEL	**249**	**274**	**250**	**274**	**294**	**280**	**268**
KC-03 CHEMICAL SCIENCES							
OPERATING (RESEARCH)	8.6	9.9	8.7	9.0	9.0	9.0	9.0
NSLS OPERATIONS	7.4	7.6	7.7	8.0	8.0	8.0	8.0
TOTAL OPERATING	16.0	17.5	16.4	17.0	17.0	17.0	17.0
CHANGES IN INVENTORIES	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAPITAL EQUIPMENT	1.5	1.8	1.0	2.1	2.1	2.1	2.1
TOTAL FUNDING	**17.5**	**19.3**	**17.4**	**19.1**	**19.1**	**19.1**	**19.1**
DIRECT PERSONNEL	**86**	**37**	**77**	**85**	**85**	**85**	**85**
KC-04 ENGINEERING AND GEOSCIENCES							
OPERATING	0.6	0.6	0.3	0.4	0.4	0.4	0.4
CAPITAL EQUIPMENT	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TOTAL FUNDING	**0.7**	**0.7**	**0.4**	**0.5**	**0.5**	**0.5**	**0.5**
DIRECT PERSONNEL	**2**	**3**	**2**	**3**	**3**	**3**	**3**
KC-06 ENERGY BIOSCIENCES							
OPERATING	1.2	1.2	1.1	1.1	1.1	1.1	1.1
CAPITAL EQUIPMENT	0.1	0.0	0.1	0.1	0.1	0.1	0.1
TOTAL FUNDING	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**
DIRECT PERSONNEL	**5**	**5**	**5**	**5**	**5**	**5**	**5**
KC BASIC ENERGY SCIENCES							
OPERATING (RESEARCH)	**20.6**	**22.9**	**20.9**	**21.3**	**21.3**	**21.3**	**21.3**
NSLS OPERATIONS	**27.7**	**28.1**	**28.4**	**28.6**	**28.6**	**28.6**	**28.6**
HFBR OPERATIONS	**22.0**	**21.9**	**22.6**	**22.9**	**22.9**	**22.9**	**22.9**
TOTAL OPERATING	**70.3**	**72.9**	**71.9**	**72.8**	**72.8**	**72.8**	**72.8**
CHANGES IN INVENTORIES	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
CAPITAL EQUIPMENT	**3.7**	**5.0**	**3.3**	**4.4**	**4.4**	**4.4**	**4.4**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 14 - FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE (IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
CONSTRUCTION							
GENERAL PLANT PROJECTS	**1.5**	**0.0**	**0.0**	**0.9**	**1.0**	**1.0**	**1.0**
CONSTRUCTION (ARAM)	**1.1**	**1.5**	**1.5**	**4.4**	**4.0**	**4.0**	**4.0**
TOTAL CONSTRUCTION	**2.6**	**1.5**	**1.5**	**5.3**	**5.0**	**5.0**	**5.0**
TOTAL FUNDING	**76.6**	**79.4**	**76.7**	**82.5**	**82.2**	**82.2**	**82.2**
DIRECT PERSONNEL	**342**	**319**	**334**	**367**	**387**	**373**	**361**
KG MULTIPROGRAM ENERGY LABS							
OPERATING							
CONSTRUCTION	0.6	1.3	6.9	6.3	14.7	24.0	21.0
TOTAL FUNDING	**0.6**	**1.3**	**6.9**	**6.3**	**14.7**	**24.0**	**21.0**
DIRECT PERSONNEL	**1**	**0**	**10**	**10**	**12**	**18**	**18**
KP BIOLOGICAL & ENVIRONMENTAL							
RESEARCH							
OPERATING	24.1	23.8	19.7	21.5	23.0	23.0	23.0
CAPITAL EQUIPMENT	2.4	-0.4	0.3	0.8	1.0	1.0	1.0
GENERAL PLANT PROJECTS				0.8	0.8	0.8	0.8
TOTAL FUNDING	**26.5**	**23.4**	**20.0**	**23.1**	**24.8**	**24.8**	**24.8**
DIRECT PERSONNEL	**112**	**97**	**96**	**105**	**107**	**107**	**107**
KJ COMP. AND TECH. RESEARCH							
OPERATING	**2.9**	**2.1**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**
DIRECT PERSONNEL	**16**	**12**	**13**	**12**	**12**	**12**	**12**
TOTALS-ENERGY RESEARCH							
TOTAL OPERATING	**204.5**	**237.3**	**226.7**	**237.4**	**238.9**	**238.9**	**238.9**
CHANGE IN INVENTORIES	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
CAPITAL EQUIPMENT	**24.5**	**25.6**	**32.4**	**32.2**	**32.4**	**32.4**	**32.4**
GENERAL PURPOSE EQUIPMENT	**1.8**	**2.0**	**4.0**	**5.4**	**5.4**	**5.4**	**5.4**
GENERAL PLANT PROJECTS	**8.3**	**7.4**	**5.4**	**13.0**	**11.8**	**11.8**	**11.8**
CONSTRUCTION	**63.3**	**20.7**	**11.0**	**20.3**	**31.3**	**49.0**	**44.2**
TOTAL FUNDING	**302.4**	**293.0**	**279.5**	**308.3**	**319.8**	**337.5**	**332.7**
DIRECT PERSONNEL	**1308**	**1220**	**1100**	**1146**	**1170**	**1162**	**1150**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 14 - FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE (IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
A/S, CONSERVATION & RENEWABLE ENERGY							
EB SOLAR AND RENEWABLE RES. TECHNOLOGIES							
OPERATING	0.8	2.2	1.8	1.8	1.8	1.8	1.8
CAPITAL EQUIPMENT	-			0.2	0.2	0.2	0.2
TOTAL FUNDING	0.8	2.2	1.8	2.0	2.0	2.0	2.0
DIRECT PERSONNEL	4	9	9	12	12	12	12
EC BUILDINGS AND COMMUNITY SYSTEMS							
OPERATING	1.2	0.8	1.0	1.1	1.1	1.1	1.1
DIRECT PERSONNEL	5	5	3	4	4	4	4
EE TRANSPORTATION							
OPERATING	2.3	(0.3)	0.9	1.2	1.2	1.2	1.2
DIRECT PERSONNEL	5	4	4	5	5	5	5
TOTALS-CONSERVATION & RENEWABLE ENERGY							
OPERATING	4.3	2.7	3.7	4.1	4.1	4.1	4.1
CAPITAL EQUIPMENT	0.0	0.0	0.0	0.2	0.2	0.2	0.2
TOTAL FUNDING	4.3	2.7	3.7	4.3	4.3	4.3	4.3
DIRECT PERSONNEL	14	18	16	21	21	21	21
A/S, ENVIRONMENT, SAFETY & HEALTH							
HC ENVIRON. ,SAFETY AND HEALTH (NON-DEF.)							
OPERATING	1.2	0.5	0.9	0.8	0.8	0.8	0.8
DIRECT PERSONNEL	3	3	3	3	3	3	3
HD ENVIRON.,SAFETY AND HEALTH (DEFENSE)							
OPERATING	1.9	0.2	0.3	0.4	0.4	0.4	0.4
DIRECT PERSONNEL	9	2	2	2	2	2	2
TOTALS-ENVIRONMENT, SAFETY, AND HEALTH							
OPERATING	**3.1**	**0.7**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**
DIRECT PERSONNEL	**12**	**5**	**5**	**5**	**5**	**5**	**5**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 14 - FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE (IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
A/S, NONPROLIF. AND NATIONAL SECURITY							
GC VERIFICATION RESEARCH AND DEVELOPMENT							
OPERATING	1.2	1.0	1.4	1.4	1.4	1.4	1.4
DIRECT PERSONNEL	9	7	7	7	7	7	7
GD NUCLEAR SAFEGUARDS & SECURITY							
OPERATING	0.4	0.3	0.4	0.5	0.5	0.5	0.5
DIRECT PERSONNEL	2	1	1	2	2	2	2
GJ ARMS CONTROL AND NONPROLIFERATION							
OPERATING	14.8	20.0	20.0	20.0	20.0	20.0	20.0
DIRECT PERSONNEL	29	28	33	35	37	37	37
CN COUNTERINTELLIGENCE							
OPERATING		0.3	0.2	0.2	0.2	0.2	0.2
DIRECT PERSONNEL		1	2	2	2	2	2
ND EMERGENCY MANAGEMENT							
OPERATING	0.3	0.3	0.3	0.3	0.3	0.3	0.3
DIRECT PERSONNEL	2	1	2	2	2	2	2
TOTALS-NONPROLIF. AND NAT'L SECURITY							
OPERATING	**16.7**	**21.9**	**22.3**	**22.4**	**22.4**	**22.4**	**22.4**
DIRECT PERSONNEL	**42**	**38**	**45**	**48**	**50**	**50**	**50**
A/S DEFENSE PROGRAMS							
DP OTHER WEAPONS ACTIVITIES							
OPERATING	**2.3**	**1.1**	**0.5**	**1.0**	**1.2**	**1.2**	**1.2**
DIRECT PERSONNEL	**11**	**4**	**2**	**6**	**7**	**7**	**7**
A/S ENVIRONMNTAL RESTORATION AND WASTE MANAGEMENT							
EW/EX ENVIRON. RESTORATION AND WASTE MGMT.							
OPERATING	26.8	29.8	32.4	32.0	32.0	32.0	32.0
CAPITAL EQUIPMENT	0.4	0.2					
CONSTRUCTION							
TOTAL FUNDING	**27.2**	**30.0**	**32.4**	**32.0**	**32.0**	**32.0**	**32.0**
DIRECT PERSONNEL	**62**	**74**	**71**	**66**	**66**	**66**	**66**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 14 - FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE (IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
A/S, FOSSIL ENERGY							
AA COAL							
OPERATING	0.2	0.3	0.4	0.4	0.4	0.4	0.4
DIRECT PERSONNEL	1	1	2	2	2	2	2
AC PETROLEUM							
OPERATING	0.7	0.3	0.4	0.6	0.7	0.7	0.7
CAPITAL EQUIPMENT				0.1	1.0	0.1	0.1
TOTAL FUNDING	0.7	0.3	0.4	0.7	1.7	0.8	0.8
DIRECT PERSONNEL	4	1	1	2	2	2	2
AZ CLEAN COAL							
OPERATING	0.1			0.1	0.1	0.1	0.1
DIRECT PERSONNEL	1			1	1	1	1
TOTALS-FOSSIL ENERGY							
OPERATING	1.0	0.6	0.8	1.1	1.2	1.2	1.2
CAPITAL EQUIPMENT	0.0	0.0	0.0	0.1	1.0	0.1	0.1
TOTAL FUNDING	**1.0**	**0.6**	**0.8**	**1.2**	**2.2**	**1.3**	**1.3**
DIRECT PERSONNEL	**6**	**2**	**3**	**5**	**5**	**5**	**5**
OFFICE OF NUCLEAR ENERGY							
CD URANIUM PROGRAMS							
OPERATING	**0.1**	**0.0**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**
DIRECT PERSONNEL							
ST ISOTOPE PROD. AND DISTRIBUTION PROGRAM							
OPERATING	**2.3**	**1.9**	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**
CONSTRUCTION - CYCLOTRON ISOTOPE RES. CTR.				**7.0**	**10.6**	**6.0**	
	2.3	**1.9**	**2.2**	**9.2**	**12.8**	**8.2**	**2.2**
DIRECT PERSONNEL	**7**	**7**	**8**	**8**	**8**	**8**	**8**
TOTALS-OFFICE OF NUCLEAR ENERGY							
OPERATING	**2.4**	**1.9**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**
DIRECT PERSONNEL	**7**	**7**	**8**	**8**	**8**	**8**	**8**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 14 - FUNDING BY ASSISTANT SECRETARIAL LEVEL OFFICE (IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
OFFICE OF SCIENTIFIC EDUCATION/TECNICAL INFO.							
KX UNIVERSITY AND SCIENCE EDUCATION							
OPERATING		**0.4**	**0.5**	**0.7**	**1.0**	**1.0**	**1.0**
DIRECT PERSONNEL		**0**	**3**	**3**	**3**	**3**	**3**
OFFICE OF POLICY, PLANNING, AND ANALYSIS							
PE POLICY, ANALYSIS AND SYSTEMS STUDIES							
OPERATING	**0.1**	**0.1**	**0.3**	**0.4**	**0.4**	**0.4**	**0.4**
DIRECT PERSONNEL	**1**	**1**	**1**	**1**	**1**	**1**	**1**
OFFICE OF CHIEF FINANCIAL OFFICER							
WN COST OF SERVICE PERFORMED		**0.1**					
OPERATING							
DIRECT PERSONNEL		**1**					
WM GENERAL ADMINISTRATION		**0.1**					
OPERATING							
DIRECT PERSONNEL		**1**					
TOTALS-OFFICE OFFICE OF CHIEF FINANCIAL OFFICER							
OPERATING	**0.0**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
DIRECT PERSONNEL		**2**					

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 15 - WORK FOR OTHERS FUNDING
($ IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
WORK FOR OTHER THAN DOE							
NUCLEAR REGULATORY COMMISSION							
OPERATING	**7.6**	**7.1**	**7.0**	**7.0**	**7.0**	**7.0**	**7.0**
DEPARTMENT OF DEFENSE							
OPERATING	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**
NAT'L AERONAUTICS AND SPACE ADMIN.							
OPERATING	1.8	1.4	3.1	3.2	3.2	6.3	6.3
CAPITAL	0.1	0.0	0.1	0.1	0.1	0.1	0.1
CONSTRUCTION - BAF	0.0	3.4	9.0	12.5	7.9	0.0	0.0
TOTAL	**1.9**	**4.8**	**12.2**	**15.8**	**11.2**	**6.4**	**6.4**
DEPARTMENT OF STATE							
OPERATING	**2.7**	**5.2**	**6.6**	**6.8**	**6.8**	**6.8**	**6.8**
NATIONAL SCIENCE FOUNDATION							
OPERATING	**1.0**	**0.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
DEPARTMENT OF HEALTH AND HUMAN SVCES.							
OPERATING	**6.1**	**15.6**	**16.3**	**16.0**	**12.0**	**12.0**	**12.0**
ENVIRONMENTAL PROTECTION AGENCY							
OPERATING	**3.3**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**
OTHER FEDERAL AGENCIES							
OPERATING	0.8	1.5	1.6	1.6	1.6	1.6	1.6
CAPITAL	0.1	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	**0.9**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**
OTHER DOE LABS							
OPERATING	12.6	7.5	7.0	7.5	7.5	7.5	7.5
CAPITAL		0.0	0.1	0.1	0.1	0.1	0.1
CONSTRUCTION - SNS	0.0	11.6	29.2	36.5	36.0	24.0	8.2
TOTAL	**13.5**	**19.1**	**36.3**	**44.1**	**43.6**	**31.6**	**15.8**
ALL OTHERS							
OPERATING	3.5	4.0	4.0	4.0	4.0	4.0	4.0
CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	**3.5**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**
TOTALS-WORK FOR OTHER THAN DOE							
OPERATING	40.7	47.4	45.9	46.4	42.4	45.5	45.5
CAPITAL	1.1	0.0	0.2	0.2	0.2	0.2	0.2
CONSTRUCTION	0.0	15.0	38.2	49.0	43.9	24.0	8.2
TOTAL	**41.8**	**62.4**	**84.3**	**95.6**	**86.5**	**69.7**	**53.9**
LABORATORY TOTALS							
OPERATING	301.9	344.1	336.7	349.1	347.2	350.3	350.3
INVENTORIES	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAPITAL EQUIPMENT	26.0	25.8	32.6	32.7	33.8	32.9	32.9
PROGRAM CONSTRUCTION	63.3	35.7	49.2	76.3	85.8	79.0	52.4
GENERAL PURPOSE EQUIPMENT	1.8	2.0	4.0	5.4	5.4	5.4	5.4
GENERAL PLANT PROJECTS	8.3	7.4	5.4	13.0	11.8	11.8	11.8
TOTAL	**401.3**	**415.0**	**427.9**	**476.5**	**484.0**	**479.4**	**452.8**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 16 - WORK FOR OTHERS PROGRAMS
($ IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
NUCLEAR REGULATORY COMMISSION							
NUCLEAR REACTOR REGULATION							
OPERATING	**2.0**	**0.7**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**
DIRECT PERSONNEL	**9**	**5**	**8**	**6**	**6**	**6**	**6**
NUCLEAR REGULATORY RESEARCH							
OPERATING	**4.7**	**4.7**	**4.3**	**4.3**	**4.3**	**4.3**	**4.3**
DIRECT PERSONNEL	**23**	**20**	**20**	**18**	**18**	**18**	**18**
COMMISSION AND STAFF OFFICES							
OPERATING	**0.9**	**1.7**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**
DIRECT PERSONNEL	**2**	**4**	**4**	**4**	**4**	**4**	**4**
TOTALS-NUCLEAR REGULATORY COMM. OPERATING	**7.6**	**7.1**	**7.0**	**7.0**	**7.0**	**7.0**	**7.0**
DIRECT PERSONNEL	**34**	**29**	**32**	**28**	**28**	**28**	**28**
DEPARTMENT OF STATE							
OPERATING	**2.7**	**5.2**	**6.6**	**6.8**	**6.8**	**6.8**	**6.8**
DIRECT PERSONNEL	**4**	**7**	**5**	**5**	**5**	**5**	**5**
DEPARTMENT OF DEFENSE							
OPERATING	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**
DIRECT PERSONNEL	**9**	**4**	**4**	**4**	**4**	**4**	**4**
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION							
OPERATING	1.8	1.4	3.1	3.2	3.2	6.3	6.3
CAPITAL	0.1	0.0	0.1	0.1	0.1	0.1	0.1
CONSTRUCTION - BAF		3.4	9.0	12.5	7.9	0.0	0.0
TOTAL FUNDING	**1.9**	**4.8**	**12.2**	**15.8**	**11.2**	**6.4**	**6.4**
DIRECT PERSONNEL	**5**	**12**	**26**	**26**	**36**	**39**	**5**
DEPARTMENT OF HEALTH & HUMAN SERVICES							
OPERATING	**6.1**	**15.6**	**12.3**	**12.0**	**8.0**	**8.0**	**8.0**
DIRECT PERSONNEL	**28**	**28**	**37**	**37**	**37**	**37**	**37**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS

Table 16 - WORK FOR OTHERS PROGRAMS
($ IN MILLIONS IN BUDGET AUTHORITY)

	FY 1998	FY 1999	FY 2000*	FY 2001*	FY 2002**	FY 2003**	FY 2004**
NATIONAL SCIENCE FOUNDATION							
OPERATING	**1.0**	**0.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
DIRECT PERSONNEL	**5**	**0**	**0**	**0**	**0**	**0**	**0**
ENVIRONMENTAL PROTECTION AGENCY							
OPERATING	**3.3**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**
DIRECT PERSONNEL	**5**	**4**	**3**	**3**	**3**	**3**	**3**
OTHER FEDERAL AGENCIES							
OPERATING	0.8	1.5	1.6	1.6	1.6	1.6	1.6
CAPITAL	0.1						
TOTAL FUNDING	**0.9**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**
DIRECT PERSONNEL	**5**	**12**	**5**	**7**	**7**	**7**	7
OTHER DOE LABS							
OPERATING	12.6	7.5	7.0	7.5	7.5	7.5	7.5
CAPITAL	0.9	0.0	0.1	0.1	0.1	0.1	0.1
CONSTRUCTION - SNS		11.6	29.2	36.5	36.0	24.0	8.2
TOTAL FUNDING	**13.5**	**19.1**	**36.3**	**44.1**	**43.6**	**31.6**	**15.8**
DIRECT PERSONNEL	**57**	**83**	**108**	**109**	**109**	**99**	**69**
ALL OTHERS							
OPERATING	3.5	4.0	4.0	4.0	4.0	4.0	4.0
CAPITAL							
TOTAL FUNDING	**3.5**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**
DIRECT PERSONNEL ***	**60**	**61**	**60**	**60**	**60**	**60**	**60**

* ESCALATION FACTORS: FY2000 AND FY2001 AT 3.6% AND 3.0% RESPECTIVELY
** CONSTANT FY2001 DOLLARS
*** Includes FTE's from Non-Reportable Programs

Table 17 - PERSONNEL BY ASSISTANT SECRETARIAL OFFICE (PERSONNEL IN FTE)

DEPARTMENT OF ENERGY PROGRAMS							
DIRECTOR, OFFICE OF ENERGY RESEARCH	1308	1220	1100	1146	1170	1162	1150
A/S CONSERVATION & RENEWABLE ENERGY	14	18	16	21	21	21	21
A/S ENVIRONMENT, SAFETY & HEALTH	12	5	5	5	5	5	5
A/S, NUCLEAR ENERGY	7	7	8	8	8	8	8
A/S, NONPROLIFERATION AND NATIONAL SECURITY	42	38	45	48	50	50	50
A/S, DEFENSE PROGRAMS	11	4	2	6	7	7	7
A/S ENVIRONMNTL. RESTORATION & WASTE MGMT.	62	74	71	66	66	66	66
A/S, FOSSIL ENERGY	6	2	3	5	5	5	5
OFFICE, SCIENCE EDUCATION AND TECHNICAL INFO.	0	0	3	3	3	3	3
OFFICE, POLICY, PLANNING, AND ANALYSIS	1	1	1	1	1	1	1
OFFICE OF CHIEF FINANCIAL OFFICER		2					
TOTAL DOE PROGRAMS	1463	1371	1254	1309	1336	1328	1316
WORK FOR OTHER THAN DOE							
NUCLEAR REGULATORY COMMISSION	34	29	32	28	28	28	28
DEPARTMENT OF DEFENSE	9	4	4	4	4	4	4
DEPARTMENT OF STATE	4	7	5	5	5	5	5
NAT'L AERONAUTICS AND SPACE ADMINISTRATION	5	12	26	26	36	39	5
DEPARTMENT OF HEALTH AND HUMAN SERVICES	28	28	37	37	37	37	37
NATIONAL SCIENCE FOUNDATION	5	0	0	0	0	0	0
ENVIRONMENTAL PROTECTION AGENCY	5	4	3	3	3	3	3
OTHER FEDERAL AGENCIES	5	12	5	7	7	7	7
OTHER DOE LABS	57	83	108	109	109	99	69
ALL OTHERS	60	61	60	60	60	60	60
TOTAL WORK FOR OTHERS	212	240	280	279	289	282	218
TOTAL LABORATORY-DIRECT	1675	1611	1534	1588	1625	1610	1534
TOTAL ORGANIZATIONAL BURDEN	190	165	151	161	161	161	161
LABORATORY DIRECTED R&D	18	26	38	45	45	45	45
TOTAL MATERIAL BURDEN	82	85	91	94	94	94	94
DISTRIBUTED/ALLOCATED SERVICES	547	597	553	555	555	555	555
TOTAL INDIRECT	545	531	590	592	592	592	592
TOTAL LABORATORY-PERSONNEL	3057	3015	2957	3035	3072	3057	2981

TABLE 18 - LABORATORY MAJOR CONSTRUCTION PROJECTS
($ IN MILLIONS IN BUDGET AUTHORITY)

		FUNDED		BUDGETED				
	TEC	FY98	FY99	FY00	FY01	FY02	FY03	FY04
Program Related - SC								
Accelerator Improvement Projects (KA)		0.9						
Accelerator Improvement Projects (KB)		1.3	1.3	2.6	9.6	11.0	11.0	11.0
Accelerator Improvement Projects (KC)		1.0	1.5	1.5	4.4	4.0	4.0	4.0
Accelerator Improvement Projects (KP)								
General Plant Projects (KA)		6.4	7.4					
General Plant Projects (KB)		0.5		5.4	11.3	10.0	10.0	10.0
General Plant Projects (KC)		1.5			0.9	1.0	1.0	1.0
General Plant Projects (KP)					0.8	0.8	0.8	0.8
Relativistic Heavy Ion Collider	486.9	59.4	16.6					
Program Related - NASA BAF	32.8		3.4	9.0	12.5	7.0		
Total:		**71.0**	**30.2**	**18.5**	**39.5**	**33.8**	**26.8**	**26.8**
Proposed Construction - SC								
Cyclotron Isotope Research Center	23.6				7.0	10.6	6.0	
RHIC Science Center	19.8					1.6	10.0	8.2
Total:					**7.0**	**22.2**	**16.0**	**8.2**
Under Evaluation								
NSLS DUV-FEL Facility								
Muon Collider Storage Ring								
Total Funded Program Construction		**71.0**	**30.2**					
Total Budgeted Program Construction				**18.5**	**39.5**			
Total Proposed Program Construction					**7.0**	**56.0**	**42.8**	**34.0**

TABLE 19 - LABORATORY MAJOR CONSTRUCTION PROJECTS
($ IN MILLIONS IN BUDGET AUTHORITY)

MEL/FS PROJECTS	Project Type	TEC	FUNDED FY98	FUNDED FY99	BUDGETED FY00	BUDGETED FY01	PROPOSED FY02	PROPOSED FY03	PROPOSED FY04
Funded/Budgeted									
Sanitary system Upgrade Ph. II (A93D0131)	1	4.3	0.6						
Electrical System Modifications Ph. I (N98D0011)	3	5.7		0.8	3.9	1.0			
Sanitary System Upgrade Ph. III (A96D0029)	1	6.5		0.5	3.0	3.0			
Total:			**0.6**	**1.3**	**6.9**	**4.0**			
Proposed - KG01									
Roof Replacement Phase II (A98D0014)	3	6.1				0.8	2.5	2.8	
Electrical System Modifications Ph. II (N98D0022)	3	6.8				0.8	3.0	3.0	
Central Steam System Rehabilitation Ph. I (N98D0046)	3	6.8					1.0	5.8	
DAT Building Ph. I (N98D0015)	5	5.0						5.0	
Roof Replacement Ph. III (A98D0193)	3	6.0							6.0
High Speed Fiber-optic Infrastructure Ph. I (N98D0007)	3	5.0							5.0
Central Steam System Rehabilitation Ph. II (N98D0020)	3	5.0							5.0
Total:						**1.6**	**6.5**	**16.6**	**16.0**
Proposed - KG02									
Ground and Surface Water Protection (A96D0029)	1	6.0				0.7	2.9	2.4	
Life Safety Code Modifications Ph. I (A92D0148)	1	5.3					5.3		
Halon System Replacement (A93D0161)	1	5.0						5.0	
Life Safety Code Modifications Ph. II (A92D0149)	1	5.0							5.0
Total:						**0.7**	**8.2**	**7.4**	**10.0**
Total GPF Funded Construction			**0.6**	**1.3**					
Total GPF Budgeted Construction					**6.9**	**6.3**			
Total GPF Proposed Construction							**14.7**	**24.0**	**21.0**
Total Funded Construction			**70.6**	**31.6**					
Total Budgeted Construction					**22.4**	**57.7**			
Total Proposed Construction							**78.2**	**87.7**	**61.2**

MEL/FS Project Types
1. ES&H Support
2. Building Rehabilitation/Upgrades
3. Utility System Rehabilitation/Upgrades
4. Roads and OSF Rehabilitation/Upgrades
5 New Building

Appendix A - R&D Portfolio Summary

The following pages list the R&D programs with the four DOE Mission Areas. Programs can appear under more than one Objective/Challenge.

Brookhaven National Laboratory

Science and Technology Mission

Extraordinary Tools for Extraordinary Science

Instrumentation for Science

Accelerator Operations	Roser, T	KA-02-01
Experimental Facilities Operations	Pile, P	KA-02-02
LHC Accelerator Collaboration	Harrison, M	KA-02-04-01
Accelerator Research and Development	Roser, T and Harrison, M	KA-04-03-01
Accelerator Test Facility Operations and Development	Ben-Zvi, I	KA-04-03-01
Inverse Free Electron Laser Accelerator Development	Gallardo, J	KA-04-03-01
Advanced Accelerator Research and Development	Palmer, R	KA-04-03-01
Accelerator R&D Infrastructure	Harrison, M	KA-04-03-01
Experimental Facilities Research and Development	Littenberg, G	KA-04-03-02
RHIC Facility Operations	Lowenstein, D	KB-02-02-011
Precision Photo-Fabrication R&D	Johnson, E	KC-02-02-02
Optics Systems for Synchrotron Radiation Applications	Takacs, P	KC-02-04-01-1
National Synchrotron Light Source Operations and Development	Hart, M	KC-02-04-01-1
High Flux Beam Reactor Operations and User Support	Reeside, W	KC-02-04-01-2
HFBR Structural Biology Facility Operation	Schnieder, D	KP-11-01-01
NSLS Structural Biology Facility Operation	Sweet, R	KP-11-01-01
Biophysical Instrumentation Research	Radeka, V and Smith, G	KP-11-01-01
Physiological Imaging	Volkow, N	KP-14-01-02-0
Brookhaven Medical Research Reactor Operations	Reeside, W	KP-14-01-05-0
Neuroreceptor Radioligands and Synaptic Activity	Gatley, J	KP-14-01-06-0

Science Simulation

Materials, Methods, Microstructure, and Magnetism	Weinert, M	KJ-01-01-03

Institutional Capacity

General Operating Support	Bari, R	DP-04-02-11-1
Safety Management Verification and Operational Readiness	Perkins, K	DP-05-14-03-0
Analytical Laboratory Management Health and Safety	Moskowitz, P	EW-40-40-00-0
Technical Support Center for Risk Excellence	Moskowitz, P	EW-40-90-20-0
Nuclear Safety Support Activity	Perkins, K	HC-11-03-10-0
Technical Support to the Office of Nuclear and Facility Safety	Carew, J	HC-11-03-20-0
Technical Assistance for Facility Safety Evaluation	Subudhi, M	HC-11-03-40-0
Integrated Safety Management Technical Assistance	Taylor, J	HC-11-05-00-0
Technical Support in Chemical Safety Monitoring	Todosow, H	HC-11-05-00-0
General Purpose Equipment		KA
Office of Science Laboratory Technology Research Program	Bogosian, M	KJ-02
Science Education Programs	Swyler, K	KX-02-01

Exploring Energy and Matter

Components of Matter

Research	Gordon, H and Dawson, S	KA-04-01-01
Laser Electron Gamma Source	Sandorfi, A	KB-01-01-02-2
Spin and Nuclear Structure Investigations with Hadronic Probes	May, M	KB-01-01-02-2
Heavy Ion Research	Chasman, C and Remsberg, L	KB-02-01-02-1
Nuclear Theory	McLerran, L	KB-03-01-02-0
National Nuclear Data Center Reference Nuclear Data for Energy Research	Dunford, C	KB-04-01-04-0
Neutron Scattering	Tranquada, J	KC-02-02-01A
Powder Diffraction	Cox, D	KC-02-02-02A
X-Ray Scattering	Gibbs, L	KC-02-02-02B
Condensed Matter Theory	Emery, V	KC-02-02-03A
Electron Spectroscopy	Johnson, E	KC-02-02-05
Structural Biology	Wall, J	KP-11-01-01
Technology Development for Protein Expression and Crystallization	Studier, F	KP-11-02-01
Genome Sequencing and Analysis	Studier, F	KP-11-03-01

Origin and Fate of the Universe

Heavy Ion Research	Chasman, C and Remsberg, L	KB-02-01-02-1
Solar Neutrino Research	Hahn, R	KB-04-01-02-2

Science and Technology Mission

Complex Systems

Neutron Scattering	Tranquada, J	KC-02-02-01B
X-Ray Scattering	Gibbs, L	KC-02-02-02
Condensed Matter Theory	Emery, V	KC-02-02-03
Electron Spectroscopy	Johnson, E	KC-02-02-05
Molecular Plant Genetics	Burr, B	KC-06

Protecting the Living Planet

Impacts on People and the Environment

EPA Regulation of Fossil Energy Technologies	Moskowitz, P	AA-15-20-15-1
Genome Sequencing and Analysis	Studier. F	KP-11-03-01
Direct and Indirect Effects of Aerosols: Short-wave Radiative Forcing by Trospospheric Aerosols	Schwartz, S	KP-12-01-03
Studies of Cloud Microphysical and Optical Properties	Daum, P	KP-12-01-03
Direct and Indirect Effects of Aerosols: Cloud Albedo Perturbations on Climate	Schwartz, S	KP-12-01-03
Chemistry and Microphysics of the Troposphere: Nanoparticle Size Distribution	Brechtel, F	KP-12-02-01
Chemistry and Microphysics of the Troposphere: Field Studies in Atmospheric Chemistry	Daum, P	KP-12-02-01
Chemistry and Microphysics of the Troposphere: Multi-Phase Atmospheric Chemistry	Lee, Y	KP-12-02-01
Chemistry and Microphysics of the Troposphere: Instrumentation for Field Programs	Springston, S	KP-12-02-01
Chemistry and Microphysics of the Troposphere: Chemical and Microphysical Aerosol Model	Schwartz, S	KP-12-02-01
Chemistry and Microphysics of the Troposphere: Aerosol Optical Properties and Phase Transformation	Imre, D	KP-12-02-01
Chemistry and Microphysics of the Troposphere: Global Emissions Inventory	Benkovitz, C	KP-12-02-01
Forest-Atmosphere Carbon Transfer and Storage-I (FACTS-I) Experiment in a Forest Ecosystem - Offsite	Hendrey, G	KP-12-02-02
Stomatal Response to CO2: A comparison of Woody and Herbaceous Species at four Free Air Carbon Dioxide Enrichment (FACE) Sites and in Arid and Humid Climates	Ellsworth, D	KP-12-02-02
Free-Air Carbon Dioxide Enrichment (FACE) Facility Development	Ellsworth, D	KP-12-03-02
Technical Program Support to Emergency Management Advisory Committee (EMAC) Subcommittee on Consequence Assessment and Protective Action (SCAPA)	Hansen, D	ND-02-02-00-0
Modifications and Refinements of the MARKAL Model	Lee, L	PE-04-01-00-0

Prevention and Protection

Asbestos Conversion Technology Development	Webster, R	EW-40-10
Technical Assistance for Office of Health	Bryce D. Breitenstein	HD-20-06-10-0
Brookhaven National Laboratory Health Surveillance System	Breitenstein, B	HD-20-06-20-0
Nucleation Dynamics in Microparticles and Chemical Characterization of Ultrafine-Particles	Imre, D	KC-03-02-02
Structure and Function in Electrochemistry	Adzic, R	KC-03-02-02
Microbial Research in Reaction Pathways/Regulatory Networks	Dunn, J	KP-11-02-02
Transformation of Heavy Metal Contaminants in Sulfate-Reducing Sub-surface Environments: The Role of Thiolated Compounds and Hydrogen Sulfide	Vairavamurthy, A	KP-13-01-01
Radiotracer Chemistry and Neuroimaging	Fowler, J	KP-14-01-02
High-Field Magnetic Resonance Imaging	Springer, C	KP-14-01-03
Microbeam Radiation Therapy for Tumors of the Central Nervous System	Dilmanian, F	KP-14-01-04-0
Neutron Capture Therapy: Preclinical Research and Clinical Investigations	Coderre, J	KP-14-01-0500
Recombinant Vehicles for Tumor Imaging and for Targeted Radioisotopic/Gene Therapy of Cancer	Srivastava, S	KP-14-01-06-0
Radioisotope Production at BLIP and HFBR	Mausner, L and Srivastava, S	ST-01-01-02

Science and Technology Mission

Fueling the Future

New Fuels

Structure-Sensitive Properties of Advanced Permanent Magnet Materials: Experiment and Theory	Welch, D	KC-02-02-02
Condensed Matter Theory	Emery, V	KC-02-02-03
Materials Chemistry	Larese, J	KC-02-03-01
Synthesis and Structures of Conducting Polymers	Mc Breen, J	KC-02-03-01
Thermal, Photo- and Radiation-Induced Reactions in Condensed Media	Sutin, N	KC-03-01-01
Interfacial Charge Transfer	Feldberg, S	KC-03-01-01
Structure-Function Designs of Photosynthetic and Catalytic Porphyrins	Fajer, J	KC-03-01-01
Study of Microgeometry of Geological Materials Using Synchrotron Computed Microtomography	Jones, K	KC-04-03-01
Geochemistry of Organic Sulfur in Marine Sediments	Vairavamurthy, A	KC-04-03-02
Modification of Plant Lipids	Shanklin, J	KC-06
Regulation of Energy Conversion in Photosynthesis	Hind, G	KC-06

Clean Power

Ex Situ Preparation of Nanocomposite Materials for Use as Anodes in Li Batteries Using the HDDR Process		EE-02-02
Mechanisms of Metal-Environment Interactions	Isaacs, H	KC-02-01-02
Superconducting Materials	Suenaga, M	KC-02-01-03
Neutron Scattering	Tranquada, J	KC-02-02-01
Powder Diffraction	Cox, D	KC-02-02-02
X-Ray Scattering	Gibbs,L	KC-02-02-02
Electron Spectroscopy	Johnson, E	KC-02-02-05
Chemistry and Electrochemistry of Hydrogen/Lithium Insertion Electrodes	Reilly, J and McBreen, J	KC-03-02-04
Materials, Methods, Microstructure, and Magnetism	Weinert, M	KJ-01-01-03

Efficient Energy Use

Studies of Nanoscale Structure and Structural Defects of Advanced Materials	Zhu, Y	KC-02-01-01
Photoinduced Molecular Dynamics in the Gas and Condensed Phases	White, M	KC-03-01-02
Gas-Phase Molecular Dynamics	Muckerman, J	KC-03-01-02
Catalysis: Reactivity and Structure	Hrbek, J	KC-03-02-01

Energy Resources Mission

Energy Security

Enhancing Domestic Supplies

Biochemical Upgrading of Oils and Petroleum Products	Premuzic, E	AC-10-15
Advanced Processes for Geothermal Brines Multiple Resources	Premuzic	EB-40-01
Geothermal Materials Development	Allan, M	EB-40-01
Natural Gas Storage Systems	Wegrzyn, J	EE-03-02

Producing Clean Fuels

CO2 Sequestration Via Utilization and Emission Reduction: An Integrated Approach to CO2 Mitigation	Mahajan, D	AA-20-25-20
Chemistry in Power Plant Plumes Tagged with Conservative Perfluorocarbon Tracers	Senum, G	AA-20-25-20

Clean and Affordable Power

Advanced Power Systems

EPA Regulation of Fossil Energy Technologies	Moskowitz, P	AA-15-20-15-1
National Photovoltaic Environmental, Health and Safety Assistance Center	Fthenakis V, and Moskowitz, P	EB-22-01-00-0

Enhancing Utility Infrastructure

Practical Conductor Development for Electric Power Systems Utilizing High-Tc Oxides	Suenaga, M and Welch, D	EB-50-01
Lithium-Ion Cell Diagnostics/Evaluation	McBreen, J	EE-02-02
Battery Materials: Structure and Characterization	McBreen, J	EE-02-02
Mechanisms of Radionuclide-Hydroxycarboxylic Acid Interactions for Decontamination of Metallic Surfaces	Francis, A	EW-40-90-10
Electroactive Materials for Anion Separation--Technetium from Nitrate	McBreen, J	EW-40-90-10

Efficient and Productive Energy Use

Efficient and Affordable Buildings

Thermal Distribution Systems in Small Buildings	Andrews, J	EC-12-02
Analysis Integration	LaMontagne, J	EC-17-01

Brookhaven National Laboratory

National Security Mission

Preventing Proliferation

Nuclear Materials Protection

Advanced Systems	Vanier, P	GC-04-04-00-0
Safeguards Science and Technology Development	Gordon, D	GD-06-04-02-0
U.S.- Russian Nuclear Security Programs	C. R. Kempf	GJ-08-00-00-0

Countering Weapons of Mass Destruction Terrorism

Nuclear Weapons

Advanced Systems	Vanier, P	GC-04-04-00-0
Safeguards Science and Technology Development	Gordon, D	GD-06-04-02-0
International Safeguards	Sanborn, J	GJ-04-00-00-0
Initiatives for Proliferation Prevention (IPP) Support	Horak, W	GJ-09-02-00-0
Policy and Technical Analysis Support	Dougherty, D	GJ-12-00-00-0

Chemical and Biological

On Site Systems	Sedlacek, A	GC-04-01-00-0
BL018 RADIAL Demonstration	Sedlacek, A	GC-04-04-00-0
Initiatives for Proliferation Prevention (IPP) Support	Horak, W	GJ-09-02-00-0
Policy and Technical Analysis Support	Dougherty, D	GJ-12-00-00-0
Technical Program Support to Emergency Management Advisory Committee (EMAC) Subcommittee on Consequence Assessment and Protective Action (SCAPA)	Hansen, D.	ND-02-02-00-0

Critical Infrastructure

Uranium Program Transparency Measures	Dougherty, D	CD-10-13-04-0
Counterintelligence (CI) Program Funding	Gross, G	CN-04-00-0
On Site Systems	Sedlacek, A	GC-04-01-00-0
International Safeguards	Sanborn, J	GJ-04-00-00-0
Initiatives for Proliferation Prevention (IPP) Support	Horak, W	GJ-09-02-00-0
Policy and Technical Analysis Support	Dougherty, D	GJ-12-00-00-0

Maintaining Current and Future Nuclear Capability

Primary Yield

Accelerator Production of Tritium	Todosow, M	DP-04-04-01-2

Detecting Proliferation

Remote Physical Detection

On Site Systems	Sedlacek, A	GC-04-01-00-0

Environmental Quality Mission

Disposal and Disposition of Wastes and Materials

High Level Waste

Reactivity of Peroxynitrite: Implications for Hanford Waste Management and Remediation	Lymar, S	EW-40-90-10-0
Radiolytic and Thermal Processes Relevant to Dry Storage of Spent Nuclear Fuel	Haustein, P	EW-40-90-10-0

Transuranic and Mixed Low Level Wastes

Decontamination of Ecolex Kinetic Mixer	Kalb, P	EW-40-10-00-0

Management of Spent Fuel

Arctic Military Environmental Cooperation (AMEC)	Moskowitz, P	EW-02-MM-03-0

Environmental Quality Mission

Disposition or Disposal of Nuclear Materials

Disposal of Boneyard Wastes	Schlender, M	EX-04-C4-01
Waste Management Operations	Schlender, M	EX-04-C4-01

Enhance Future Land Use

Remedial Action

Glen Cove W/BHG	Moskowitz, P	EW-40-10-00-0
Completion/Development of PFT Tech	Sullivan, T	EW-40-10-00-0
BNL Environmental Restoration and Waste Management - Remedial Actions	Schlender, M	EX-04-C4-01
Environmental Restoration - Program Management	Schlender, M	EX-04-C4-03
Stabilization of Radionuclides by Anaerobic Bacteria: Molecular Genetic Analysis of Clostridia	Dunn, J	KP-13-01-01

Deactivation and Decommissioning

BGRR Deployment Plan	Moskowitz, P	EW-40-10-00-0
Decontamination and Decommissioning	Schlender, M	EX-04-C4-02

FY1999 Draft DOE Laboratory Profile for Brookhaven National Laboratory

The information presented in the draft DOE Profile for BNL should not be compared directly with the information contained in this plan or with the DOE profiles for other Laboratories. The draft DOE profile is constructed using different guidelines. For example, the environmental remediation program funds and funds received from other DOE Laboratories and Operations Offices are not included in the Draft DOE profile for BNL, but are included in the profiles presented in this plan.

Brookhaven National Laboratory

Pre-decisional Draft 3/3/99

Laboratory Mission Profile

Laboratory Information

Name:	Brookhaven National Laboratory
Location:	Upton, New York
No. of Full-Time Employees:	3057
cientific and Technical Degrees:	618 923 Bachelor's/Master's
Contractor:	Brookhaven Science Associates
Accountable Program Office:	Science
Field Office:	Chicago Operations Office
Web Site:	http://www.bnl.gov

Funding Sources

Science: $302.4M
Enviromental Management: 7.6M
Nuclear Non-Proliferation: $16.6M
Conservation and Renewable: $4.3M
Environment, Safety and Health: $3.1M
Nuclear Energy: $2.4M
Other DOE: $3.4M
Non_DOE: $28.2M

Total Funding: $368.0 million

Note: Budget data shown are for FY98 and exclude remediation (cleanup) funds.

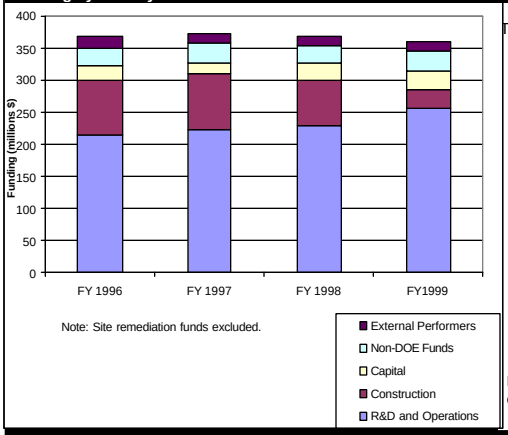
Description

Brookhaven National Laboratory founded in 1947 as a center for research in nuclear sciences and related fields,is noted for the design, construction and operation of large scale, cutting edge research facilities and for fundamental research in matter and energy and the properties of materials. In 1999, Brookhaven will begin operations of the Relativistic Heavy Ion Collider, the worlds largest facility for the study of conditions of density and temperature that occurred microseconds after the Big Bang. Over 4000 scientist from the US and abroad come to the Laboratory each year to use BNL's facilities, and to participate in joint scientific ventures with the staff. This outstanding mix of machines and expertise four times produced work that earned the Nobel Prize. Research at BNL led to the development of medical diagnostics, the treatment of Parkinson's disease with L-Dopa, and creation of the National Sycnhrtron Light Source, that now provides 60% of the nations synchrotron research capacity. The Laboratory will continue to provide innovative facilities and produce forefront research that permit researchers form all over the world to make the link between the fundamental knowledge of the structure of matter and energy with the practical technologies needed to address the problems of society.

Distinctive Competencies and Major Facilities

The Laboratory's **core competencies** are the design, construction, and operation of advanced research facilities, the development of advanced detectors, and production of superconducting magnets. Research focuses on the physics of matter and energy; chemical sciences, (e.g.; photoconversion, catalysis, radiation chemistry, electron transfer, gas phase dynamics); materials science (e.g.; magnetism, superconductivity, corrosion); life sciences (e.g.; molecular genetics, structural biology, genomics, radiation effects, medical imaging, cancer research); environmental science (carbon management, atmospheric chemistry and bioremediation), and nuclear science and technology, nuclear non-proliferation. BNL is distinguished within the DOE system by its many unique facilities. The **Relativistic Heavy Ion Collider (RHIC)** will begin operations in 1999. It will be the largest facility for nuclear physics in the US and the most powerful source of heavy ion collisions in the world, creating conditions that occurred microseconds after the Big Bang. RHIC will offer potential for new discoveries about the most fundamental structure of matter. The **National Synchrotron Light Source (NSLS)** is a user facility providing high intensity x-ray, ultraviolet and infrared light to 85 beamlines. Researchers in applied sciences, chemical sciences, materials and life sciences from 350 institutions use the NSLS. The **Alternating Gradient Synchrotron (AGS)** is a proton accelerator with the highest-intensity high-energy proton beams in the world, and a source of polarized protons for over 800 users. Coupled to the Tandem Van de Graaff, the AGS can accelerate heavy ions. It will be the injector for RHIC, and will provide beams for the NASA Booster Application Facility. Brookhaven is one of the laboratories contributing to the design and development of the new Spallation Neutron Source. The **High Flux Beam Reactor (HFBR)** was designed for research in the physical, chemical, biological, medical and environmental sciences. The **Center for Imaging and Neuroscience (CIN)** provides three imaging modalities for studies of the brain; positron emission tomography (PET), magnetic resonance imaging (MRI), and single photon emission computer tomography (SPECT). The current activities include research on aging, addiction, and normal brain function. The **Accelerator Test Facility (ATF)** is a unique user facility for the development of new accelerator concepts. Current R&D effort will form the basis of the next generation light sources with the development of short wavelength free electron lasers.

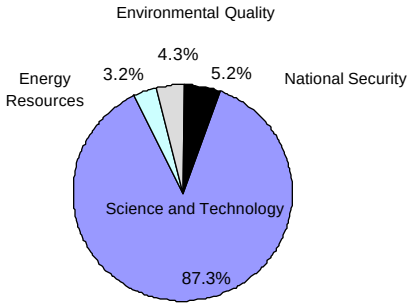
Funding by Activity



Note: Site remediation funds excluded.

DOE R&D Footprint

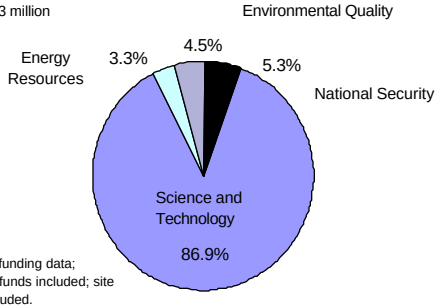
Total Mission: $368.0 million



Note: Based on FY98 funding data; contributing non-DOE funds included; site remediation funds excluded.

DOE Mission Footprint

Total R&D: $357.3 million



Note: Based on FY98 funding data; contributing non-DOE funds included; site remediation funds excluded.

Brookhaven National Laboratory

Pre-decisional Draft 3/3/99

Key Research and Development Activities

Science and Technology: Research and development activities in nuclear and high energy physics, basic energy sciences, and biological and environmental sciences.

- In **High Energy and Nuclear Physics**, major activities are design, construction and operation of the Relativistic Heavy Ion Collider (RHIC), operations and research at the Alternating Gradient Synchrotron, research on advanced accelerator concepts, and research in particle and nuclear physics. Research includes experimental and theoretical high energy, nuclear and condensed-matter physics. The Laboratory's experimenters also conduct research at other accelerator facilities such as Fermi Accelerator National Laboratory, Thomas Jefferson Lab, and CERN in Switzerland. Experiments at the Laboratory include precision measurement of the muon g-2, search for exotic mesons, and studies of rare kaon decay. With the start up of RHIC, researchers will begin looking for the quark-gluon plasma and exploring and characterizing new states of matter.
- The Laboratory is collaborating with NASA on a Booster Application Facility that will simulate aspects of space radiation environment. It also is the lead in the Large Hadron Collider (LHC) Project, hosting US participation in one of the two LHC detectors, and managing the preparation of US scientists for collaborations in the LHC physics program. The Laboratory also has a leadership role in the Muon Collider Collaboration.
- In **Basic Energy Sciences**, BNL supports the major neutron and photon user facilities in the northeastern US. Over 2000 scientists from the US and abroad perform experiments on one of the 85 beamlines at the NSLS which provides 60% of the US capacity in synchrotron based research. All modern light sources are based on the unique brightness lattice developed at the NSLS. The size and complexity of the NSLS requires a high level accelerator and engineering staff to maintain and enhance the performance of the source, as well as a diverse beamline staff to assure smooth operations and development of new applications of synchrotron radiation. Users at the NSLS come from such diverse fields as chemistry, biology, physics, material science, geology and environmental science. Their research includes very basic studies, such as the electronic structure of solids and surfaces, crystallography of macromolecules, development of imaging techniques, and development of new materials. In recent years, there has been a significant increase in the number of researchers in Life Sciences who rely on the NSLS to further their research goals.
- The High Flux Beam Reactor has been a leading center for neutron science for over 30 years. The design of the High Flux Beam Reactor (HFBR) is the basis for the other high flux reactors. Its nine experimental ports support programs in solid state and nuclear physics, chemistry and structural biology. Research at the HFBR includes, neutron crystallography of complex sugars and amino acids, as well as fast-ion conductors, materials that are important in batteries; studies of polymers that may be used to clean up oil spills, and research on radiopharmaceuticals.
- The Laboratory has active collaborations with Argonne National Laboratory, the Stanford Linear Accelerator Center and Lawrence Livermore National Laboratory in developing the fourth generation particle photonic devices, and plays a role in several areas in the construction and operation of spallation neutron sources.
- Research activities involve **materials sciences, chemical sciences, geosciences and energy bioscience**. Many of the programs in materials science use beamlines at the NSLS and the HFBR to study fundamental interactions in solids, and the role of defects in the macroscopic properties of materials. Current studies include high temperature superconductivity, magnetism and the electronic properties of surfaces and adsorbed films. These programs are closely coupled to the programs in condensed matter theory. In chemical sciences, several programs are pursuing research in photochemistry and radiation chemistry, chemical physics and chemical energy including the exploration of efficient capture and storage of light energy, photodecomposition of water and of carbon dioxide, the study of homogeneous catalysis. Programs to understand carbon sequestration include the role of porphyrins in bioenergetic reactions such as photosynthesis, and electrochemical studies of the role of electron transfer.
- In Geosciences, the NSLS is used for x-ray microtomography of geological samples to determine fluid flow and mechanical properties in porous media, and to study the distribution of trace metals in plants and insects. The goal of fundamental and applied research in energy bioscience is to understand the genetic, physiological and biochemical mechanisms of higher plants.
- In **Biological and Environmental Science** activities include medical application of nuclear technology, basic and applied molecular, structural, cellular, and radiation biology, epidemiology, and environmental research. Several Laboratory centers and facilities were developed and operated through partnerships with and funding from the National Institute of Health and other agencies. These include the development of facilities for synchrotron crystallography at the NSLS and support for the Center for Imaging and Neuroscience and the Scanning Transmission Electron Microscope. The facilities for structural biology at the NSLS, HFBR and STEM represent a powerful combination of tools for examining the structure of macromolecules. Genome research focuses on human and microbial genome sequencing. The imaging and neuroscience programs are developing imaging techniques, and applying imaging modalities to study diseases and addictions. The Laboratory has programs to develop new detection methods and treatments of cancer, and it supplies isotopes for medical diagnosis, and researches new radiopharmaceuticals for diagnosis and treatment. The environmental programs focus on developing the information and models for the transport and fate of fossil fuel atmospheric pollutants. The Laboratory participates in multi-Lab and University collaborations addressing several key aspects of global change and carbon management. It leads the Free Air Carbon Dioxide Enrichment (FACE) program, which involves expose ecosystems to elevated levels of carbon dioxide in a controlled fashion. The Laboratory also has a principal role in the DOE Atmospheric Radiation Measurement program and Atmospheric Chemistry programs, and participates in a multi-laboratory collaboration to integrate various tasks in Department's climate change response with other agency (NOAA and NASA) programs

Energy Resources: The Laboratory's activities are; the development of geothermal power and materials for use in geothermal applications; microbial treatment of geothermal brines; the use of biotechnology to upgrade heavy oil, the improvement of residential heating systems, and ways to reduce emissions from the use of fossil fuels. The Laboratory is a major contractor for the NRC and has partnered with PNNL in an effort to reduce the risk of Soviet reactors.

Environmental Quality:. The Laboratory's role in Environmental Quality is dominated by activities to restore the BNL site and to effectively manage the waste generated by R&D programs. The Office of Biological and Environmental Research also funds research programs related to remediation and waste management.

National Security: Programs for the development of advanced technologies to aid in detecting and countering proliferation threats, providing technologies to the US to support treaty verification and to prevent, detect, and respond to events involving weapons of mass destruction. The Laboratory collaborates with other national laboratories to determine the structures of critical toxins that might be used by terrorist or in warfare, and in collaborations with other laboratories in designing and installing nuclear material protection, control and accounting systems in the Former Soviet States.

Significant Accomplishments

Many of the most significant accomplishments are the direct result of the extraordinary facilities available at BNL.

- The **Alternating Gradient Synchrotron (AGS)** has been one of the most productive high-energy facilities in the world. In 1998, the AGS produced the worlds highest intensity, high-energy proton beam, the world's largest superconducting magnet went on line at the muon g-2 experiment, and scientist observed the first very rare kaon decays. Research at the AGS has led to increased understanding of the nature of matter. Of particular significance are; the Nobel Prize for demonstration of the existence of two kinds of neutrinos (1985), a Nobel prize for discovery of CP violation in the decay of neutral K mesons (1980), a Nobel Prize for discovery of the J/psi particle (1976), and discovery of the omega minus hyperon (1964). The AGS is the first accelerator based on the principle of strong focusing (1952) which is now the design used worldwide.
- **National Synchrotron Light Source (NSLS)** is one of the most heavily used facilities in the world. Accomplishments resulting from work at the NSLS include; crystal structures of many biological structures such as that of gp120 (1998) by researchers from Columbia University, which reveals how HIV virus binds to the receptor; development of a scanning x-ray microscope, applicable to many studies in biology and materials science (1996); development of the small undulator gap design which changes the design rules for the next generation x-ray sources (1995); development of medical x-ray imaging techniques for mammography (1995) and coronary angiography (1991); development by Lucent technologies of projection VUV lithography (1990); development of x-ray microtomography to study fluid flow in rock (1987); development of x-ray lithography by IBM (1983). All modern light sources are based on the unique high brightness lattices developed at the NSLS (1975, Chasman-Green lattice)
- The **High Flux Beam Reactor** has been a major tool for neutron studies in condensed matter and nuclear physics, chemistry, and biology. Significant accomplishments include; development of tin-117m DTPA as a possible treatment for bone cancer (1995); discovery of electron transport in 'stripes' in high temperature superconductors (1995); elucidation of the mechanism of Adamantaine in the treatment of influenza A (1994), determination of the structure of higher order packaging of DNA and nucleosome cores in human cells (1994); work that established the structure of plasminogen and enabled the development of effective intervention in heart attack and stroke patients (1990).
- **Center for Imaging and Neuroscience:** BNL has been a leader in the pursuit of understanding how the brain functions. The most recent accomplishments were the determination that therapeutic doses of Ritalin were safe for children and that an epilepsy drug might offer an effective treatment modality for cocaine abuse (1998). These breakthroughs studies follow quickly the discovery that dopamine receptors and transporters in the human brain decline in tandem with normal aging (1998); the imaging of the binding sites of nicotine in the human brain (1996); the first use of robotics in plasma analysis for PET (1995); and development of a graphical analysis system for kinetic analysis of reversibly binding radiotracers (1990), an analysis that is now used worldwide. BNL is responsible for the pioneering work demonstrating the use of imaging to study interactions between neurotransmitters in the human brain (1987), advances made possible because of the synthesis of Fluorine-18 fluorodeoxyglucose, FDG (1979), the major PET radiotracer in the world for research on the brain, and for diagnosis of heart disease and cancer.
- **Face Facility:** Studies of tree growth in the Duke Forest FACE Facility by BNL have shown unusually large increases in growth rate of Loblolly pines exposed to twice the normal carbon dioxide.

Other Significant Accomplishments.

- Successful bioengineering of desaturase, an approach that may revolutionize the production of feedstocks from plants (1997)
- First clinical trials using Boron phenylalanine to treat malignant brain tumors with neutron irradiation (1994).
- Demonstration that Ultraviolet A as well as Ultraviolet B can cause melanoma (1993).
- Developed primers for deciphering DNA (1992). This system hold promis for faster sequencing of genomes
- Developed infrared beamline. This formed the basis of other beamlines proposed for other synchrotron facilities (1990).
- Studies to show that cocaine abusers have abnormally low brain dopamine activity (1990).
- Development of a real time feedback system to stabilize the entire orbit in a storage ring. These systems improved the stability at the NSLS by an order of magnitude (1989).
- Recombinant inbreds used to map genes in plants. This is now widely used commercially for mapping plant genes (1988).
- Developed instrumentation and software for quantifying DNA damage in human and plant cells (1987).
- Discovered the second high Tc superconductor (1986).
- Verified the importance of nuclear configuration changes, bridging groups, and solvents in determining electron transfer rates (1985).
- Discovered and characterized the first human enzyme required for DNA repair for damage from ionizing radiation (1983).
- Invention of a 2 in 1 superconducting dipole (1982).
- Discovered DNA mismatch repair (1982).
- Established the Protein Data Bank (1971)
- Developed first prototype Positron Emission Tomography (PET) for brain research (1970).
- Invention of Magnetically Levitated trains (1968).
- Developed L-dopa treatment for Parkinson's disease (1965).
- Thallium radiopharmeceutical developed for use in stress test (1965).
- Synthesis of human insulin (1964).
- Technetium-99m radiopharmeceutical developed for medical imaging.(1960) Used 63,000 times each day.
- Research in hot atom chemistry of C-14 and C-11 that lays the groundwork for future development of radiotracers used to study the brain (1955).
- Confirmed the theory of associated production of strange particles (1950).
- Verified the kinetic isotope effect (1949). Techniques based on this effect are used in the study of chemical reaction mechanisms.

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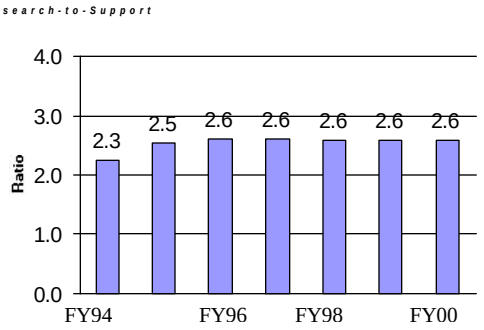
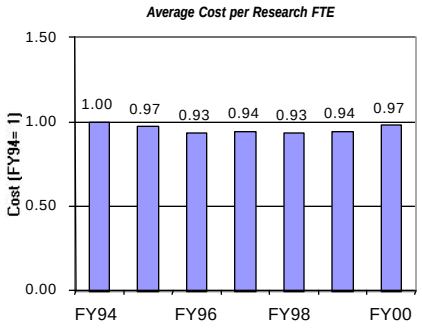
Major Partnerships, Collaborations, and CRADAs

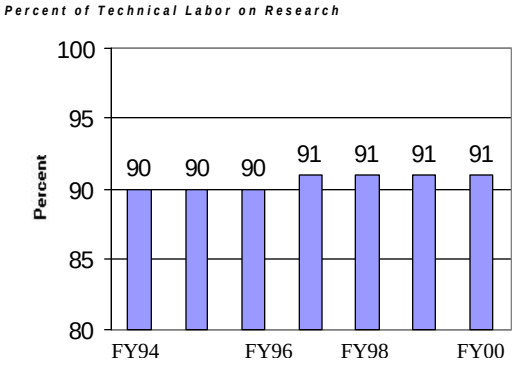
Brookhaven National Laboratory engages in many partnerships and collaborations with other DOE Labs, other Federal Agencies, universities, industry and international institutions. Most of these are a direct result of the Laboratory's lead role in Science and Technology and the number of unique user facilities available for research. Each year more than 4000 visiting scientists use BNL's facilities and work with BNL staff.

Category/Mission	*Partner*	*Description*
Science and Technology	Multinational Collaboration	RHIC detector development and experimental proram (5 DOE Labs, 35 US Universities, 46 International Institutions). See http://www.rhic.bnl.gov
	FNAL, LBNL, CERN	Large Hadron Collider, Muon Collider
	ORNL, LBNL, ANL, LANL	Spallation Neutron Source
	Multinational Collaborations.	Experimental program at the AGS including muon g-2 measurement, search for short lived dibaryon, exotic mesons, and novel forms of matter, very rare K(+) decays, spallation neutron targets. (61 US Universities, 52 International Institutes, 9 DOE Labs). See http://.www.rhichome.bnl.gov/AGS/
	NASA	Booster Applications Facility designed to study effects of radiation that may be encountered in deep space travel.
	DOE, Other Federal agencies, Universities, Industry, International Institutions	Experimental progrms at the NSLS including; medium energy physics, structural biology, structural determination of metal, surfaces, films and other complex materials, studies of catalysts and polymeric materials, semiconductors and alloys. (2000 users from 350 institutions/agencies). See http://www.nsls.bnl.gov
	Rockefeller University, Einstein College of Medicine	Research and development in functional and structural genomics.
	5 Universities and 3 Federal agencies	Bio-medical research such as imaging studies, research in neurosciene, development of positron emitters, crystallography at the NSLS, operation of the STEM, protein structure and function, DNA damage and repair
	3 Industries	Research including, neutron activation for clinical reseach in AIDS, anorexia and obesity; development of immunological reagents for analysis of DNA damage response; radioisotope production for PET.
Energy Resources	10 US Industries	Microaccelerator auto crash sensors, thin film batteries, development of corrosion inhibitors, catalytic production of organic chemicals.
	NRC	Technical assistance, regulatory research, operation of high temperature combustion facility, studies of age related mechanisms on cable aging and degradation.
	PNNL	Safety of Soviet Reactors
Environmental Quality	U. Minnesota	Design, engineering and construction of FACE facility.
	EPA, NASA	Remediation of NY Harbor (EPA). Aerosol microphysics (NASA).
National Security	Dept. of State, FAA	Support to International Atomic Energy Agency in nuclear safeguards and safety of Soviet Reactors (Dept. State). Aircraft Reliability (FAA)

Performance Metrics







FY 94 to 97: Actual
FY 98 to 00: Projected

Appendix B -User Facility Data

Experimenters at User Facilities

Industrial and Technological Users of the NSLS

Industrial and Technological Users the Tandem Facility

For information on BNL User Facilities see the following WEB addresses:

Facility	WEB ADDRESS
Alternating Gradient Synchrotron:	http://www.rhichome.bnl.gov/AGS/ and http://www.rhichome.bnl.gov/AGS/ags.html#exp
National Synchrotron Light Source:	http://www.nsls.bnl.gov/ and http://www.nsls.bnl.gov/BeamLine/pages/BL-index.htm
Relativistic Heavy Ion Collider:	http://www.rhic.bnl.gov/ and http://www.rhic.bnl.gov/html2/experiments.html
Tandem Van De Graaff:	http://www.tvdg.bnl.gov/tvdg.html
Accelerator Test Facility:	http://www.nsls.bnl.gov/AccTest/Menu.html
Scanning Transmission Electron Microscope:	http://bnlstb.bio.bnl.gov/biodocs/stem/stem.htmlx

Table 20 - EXPERIMENTERS AT USER FACILITIES

Facility	Number of Experimenters	Number of Organizations
RELATIVISTIC HEAVY ION COLLIDER		
BNL	108	1
Other Federal Labs	128	6
University	273	36
Industry	0	0
International	434	47
	943	**90**
ALTERNATIVE GRADIENT SYNCHROTRON		
BNL	88	1
Other Federal Labs	51	12
University	332	52
Industry	2	1
International	280	44
	753	**110**
NATIONAL SYNCHROTRON LIGHT SOURCE		
BNL	220	1
Other Federal Labs	279	25
University	1213	141
Industry	264	61
International	354	132
Other	50	10
	2380	**370**
TANDEM VAN DE GRAAFF		
BNL	5	1
Other Federal	30	5
University	4	1
Industry	28	13
International	26	5
	93	**25**
SCANNING TRANSMISSION ELECTRON MICROSCOPE		
BNL	8	1
University	53	28
Other Federal Labs	5	2
Other	5	2
	71	**33**
ACCELERATOR TEST FACILITY		
BNL	19	1
Other Federal Labs	23	5
University	16	11
Industry	4	14
International	4	1
	66	**32**

Table 21 - INDUSTRIAL AND TECHNOLOGICAL USERS OF THE NSLS	
3-Dimensional Pharmaceuticals, Inc.	Abbott Laboratories
Advanced Fuel Research	Air Products & Chemicals Inc.
AlliedSignal, Inc.	Amoco Corporation
Applied Physics Technologies Corp.	Area Detector Systems Corporation
Bayer Corporation	Bechtel Nevada
BioSpace International Inc.	**Biological Research Center**
Boehringer Ingelheim Pharmaceuticals, Inc.	Bristol-Myers Squibb
Bruker AXS, Inc.	Chevron Research & Technology Company
Containerless Research. Inc.	Corning, Inc.
Crystal Technology, Inc.	David Sarnoff Research Center
Digital Equipment Corporation	Dow Chemical Company
Eastman Chemical Company	Eastman Kodak Co.
Edge Analytical, Inc.	Emerald BioStructures, Inc.
Enraf-Nonius, Inc.	Ethicon, A Johnson & Johnson Company
Exxon Research and Engineering Co.	General Electric
GlaxoWelcome, Inc.	Hoechst Celanese
Hoffmann-La Roche	IBM Research Division
IKV Petroleum Research	Instituto Tecnologico de Aeronautica (ITA)
KLA Instruments	Kawasaki Heavy Industries, Ltd.
Kinetix Pharmaceuticals, Inc.	Lockheed Engineering
Lucent Technologies, Inc.	MVA, Inc.
Matsushita Electric Industrial Co., LTD	Memstek Products, LLC
Merck & Co.	Mobil R&D Corp.
Molecular Structure Corporation	Montell Polyolefins USA
NEC Corporation	NHK Enterprises American, Inc.
Northrop Grumman ATDC	On-Line Technologies Inc.
Oxford Instruments	PPG Industries, Inc.
Pall Corporation	Panametrics, Inc.
Pfizer, Inc.	Procter & Gamble Co.
Quantum Devices, Inc.	R&D Services, Prop.
Rohm & Haas Co.	SFA, Inc.
Sarnoff Corporation	Sci-Med
Science Applications International Corp.	SmithKline Beecham Pharmaceuticals
Southern Research Institute	Spectra-Tech Inc.
St. Gobain Industrial Ceramics	TYCOM
Texaco Research Center	The DuPont Company
The EXAFS Company	UOP
Vertex Pharmaceuticals, Inc.	Wyeth-Ayerst Research

Table 22 - INDUSTRIAL AND TECHNOLOGICAL USERS OF THE TANDEM FACILITY

Airborne Instruments Laboratory	LSI Logic, Inc.
AK Research, Inc.	Martin Marietta
ALCATEL Espace (France)	Matra Marconi Space (France)
Alliance Technologies, Inc.	Matra MHS (France)
Allied Signal	McDonnell-Douglas Corporation
APTEK, Inc.	Mission Research Corporation
AT&T	Mitsubishi Electric
Ball Aerospace Corporation	Motorola, Inc.
Boeing North America	Myers & Associates
Booz, Allen and Hamilton	NASA/Goddard Space Flight Ctr
Centre Spatial de Toulouse (France)	NASA/Johnson Space Center
CertOnera (France)	NASDA (Japan)
Clemson University	Nat'l Security Agency (NSA)
Computing Devices, International	Naval Research Lab (NRL)
Control Data Corporation	Naval Surface Warfare Center
Corning Costar Corporation	NEC Corp. (Japan)
Defense Nuclear Agency (DNA)	Novus Technologies
Diamond Materials, Inc.	Physitron Corporation
Electromagnetic Sciences, Inc.	Polytechnic University
Epitaxx	Raymond Engineering
European Space Agency (ESA)	Raytheon
Fairchild Space Co.	Raytheon TI
Grumman Aerospace Corporation	Research Triangle Institute
Hampton University	Rocketdyne Corporation
Harris Corporation	Rockwell International
HIREC Corp. (Japan)	SAAB Space Components Lab
HIREX (France)	Sandia National Laboratories
Honeywell (SASSO)	Santa Barbara Research Center
Honeywell (SSEC)	S-Cubed
Hughes Aircraft Corporation	Space Electronics
Hughes/Danbury Optical Corp.	Spectrum Astro
IBM	Spectrum Sciences
Idaho National Engineering Lab	Toshiba Corp.
Innovative Concepts	TRAD (France)
International Rectifier Corp.	TRW
Jet Propulsion Laboratory (JPL)	University of Idaho
Johns Hopkins University (APL)	University of Maryland
Lehigh University	University of New Hampshire
Lockheed Martin Aerospace Corp.	University of NM (NASA/MERC)
Lockheed Martin Corporation	USAF Phillips Laboratory
Lockheed Martin Federal Systems	Utd Tech Microelectronics Ctr
Lockheed Missiles & Space Corp.	

Appendix C - Work For Others and Technology Transfer Information

National Aeronautics and Space Administration (NASA): The AGS currently is accelerating Fe ions to energies up to 1.0 GeV per nucleon in a radiobiology program for NASA's Space Radiation Health and Radiation Biology Division. This work will expand a very limited experimental data-base on long missions into interplanetary space by humans. This program runs for two weeks of beam-time per year, with heavy-ion irradiation's for 20-30 experiments annually. The users are approved and funded by NASA, which purchases the AGS time.

National Institute of Health (Department of Health and Human Services): Several of BNL's centers and facilities are developed and operated through partnerships with, and funding from, the National Institute of Health. Such partnerships include the development of facilities for synchrotron crystallography at the NSLS as well as support to our Center for Imaging and Neuroscience and the Scanning Transmission Electron Microscope. NIH also provides substantial support through research grants to individual investigators in the field of molecular Biology.

Environmental Protection Agency (EPA): New York Harbor is faced with an operational crisis in removing sediments and soils contaminated with a variety of anthropogenic toxic materials.. The crisis was brought about by stricter regulations that reduce the amount of dredged material considered suitable for ocean disposal in the coastal Atlantic. Supported by EPA Region 2, this project investigates commercial technologies for decontaminating sediments.

International cooperation is critical to achieving EPA's mission. The EPA Office of International Activities (OIA) enlists the cooperation of other nations in solving environmental problems of concern to the United States. BNL staff are assisting this office in designing and overseeing the construction of a waste processing facility in Murmansk, Russia. We are providing technical support in evaluating Russian waste treatment technologies, and, through OIA, are fostering environmentally sound, sustainable development initiatives in Kazakstan.

Department of Defense (DOD): With DARPA funding, we developed a novel high-performance oil-fired thermo-photovoltaic system for generating electric power under field conditions. Currently, we are scaling up and refining the design.

Under sponsorship from the Defense Special Weapons Agency, we also are applying ultra-sensitive Plutonium Screening and Sampling Protocols used in the DOE funded Marshall Island dose-assessment program, to assay Pu-238 uptake in veterans who participated in above-ground nuclear testing, or in the occupation of Hiroshima and Nagasaki.

Finally, we support the U.S. Army in the Chemical and Biological Defense Command (CBDCOM) by assessing the fluorescence properties of humidified and coated biological particles.

U.S. Nuclear Regulatory Commission (NRC): BNL's staff engage in a range of technical assistance and experimental and theoretical regulatory research for the NRC. This work includes integrated risk assessment and reliability analysis, thermal-hydraulic and neutronic-analyses, evaluations of degraded core- and fission-product releases, determination of the containment response, offsite-consequence modeling, human-factors analysis, structural-, mechanical- and earthquake-engineering analysis, operational safety assessments, acceptability reviews of plant-specific safety issues, and appraisals on fire-protection features in nuclear power plants.

BNL constructed and operates for the NRC the High-Temperature Combustion Facility (HTCF), a unique facility for investigating high-temperature, high-speed combustion phenomena (including detonations). The Laboratory provides valuable information on the environmental qualification of aged electrical cables using experimental condition-monitoring resources housed in our Electric Cable Test Facility. BNL has given training and technical support in ALARA, and is heavily involved in technology transfer and training of regulatory staff in the countries of the former Soviet Union. We also collaborate in seismic research with NUPEC of Japan.

Department of State (DOS): The Department of State funds Brookhaven's International Safeguards Project Office (ISPO) which supports the IAEA in nuclear safeguards. ISPO provides ongoing technical review and management of the U.S. Program of Technical Assistance to IAEA Standards (POTAS), as well as advice on new initiatives to enhance the effectiveness and efficiency of IAEA safeguards. Currently, ISPO tracks nearly 100 active projects. Additional funds may be secured for initiatives focussing on managing Russian radioactive waste.

Federal Aviation Administration (FAA): BNL staff have used their expertise in risk- and reliability-analysis and assessments of threats by insiders and outsiders to assist several branches of the FAA in aircraft system reliability, availability, maintainability, and in airport security. Two members of our staff were appointed by the FAA to a Blue-Ribbon Panel in response to the White House Commission on Aviation & Security. Several others are employing probabilistic-risk analysis techniques, which were honed through applications to nuclear power plants, to glean risk-related insights from recent incidents and accidents in commercial aircraft and for improving the reliability of specific aircraft components.

Table 23 - FY 99 WORK FOR OTHERS BY PROJECT

FUNDING AGENCY	TITLE	DEPARTMENT
	DEPARTMENT OF COMMERCE	
NOAA	Compilation and Analyses of Emissions Inventories for the North Atlantic Regional Experiment	DAS
NOAA	Ferredoxin & Flavodoxin as Metabolic Markers for Iron Stress	DAS
NOAA	Development and Deployment of an Aircraft Formaldehyde Measurement During NARE	DAS
NIST	Development & Scientific Application of Neutron Crystal Spectrometers for Materials Research	PHY
NOAA	Diagnostic Model Studies on Seasonal Changes in Chemistry in NARE	DAS
	DEPARTMENT OF DEFENSE	
DARPA	Molecular Logic Gates	MED
SERDP	Non-destructive Evaluation of Corrosion Under Coatings	DAS
ARMY	Design, Development & Fabrication of a Breadboard Prototype 500W TPV Power Source Phase I	DAS
ONR	Shipboard Acoustic Doppler Profiles in the Arabian Sea	DAS
ONR	A Spectral Element, Eddy, Resolving Primitive Equation Model for the North Atlantic	DAS
ARMY	Amorphous Pre-ceramic and Crystalline Organic Polymers for High Performance Coatings, Adhesives, and Composites	DAS
Navy	Chemical Digestion Process	DAS
Army	Active/Passive Noise Cancellation	DAS
Navy	Arctic Military Environmental Cooperation	DAT
DNA	Improvement of FTA Fission Track Analyses of Urine Samples From The Nuclear Test Personnel Program...	DAT
	DEPARTMENT OF HEALTH AND HUMAN SERVICES (DHHS) - PROGRAM 40	
NIH	Chemistry Department Operating Funds for Regional NIDA Neuroimaging Center	MED
NIH/NIDA	Operating Funds for Regional NIDA Neuroimaging Center	MED
NIH	Protein Data Bank	BIO
	DHHS GRANTS	
NIH	DNA Mismatch Repair in Transformation and Mutagenesis	BIO
NIH	Function of the Human DNA Activated Protein Kinase	BIO
NIH	Regulation of Adenovirus Proteinase by a Peptide J DNA	BIO
NIH	The Dual Receptor Mechanism of Adenovirus Infection	BIO
NIH	STEM Mass Mapping & Heavy Atom Labeling of Biomolecules	BIO
NIH/NIGMS	Structural and Functional Studies of E Coli DNAJ	BIO
NIH	Development for Macromolecular Crystallography at the NSLS	BIO
NIH	CLP: An Archetypal ATP-Dependent Protease	BIO

Table 23 - FY 99 WORK FOR OTHERS BY PROJECT

FUNDING AGENCY	TITLE	DEPARTMENT
NIH	Enhancement of Functional and Neurochemical Brain Pattern	CHEM
NIH/NINDS	Pet Studies of Catechol -O-Methyltransferase	CHEM
NIDA	PET in Cocaine Abuse	CHEM
NIH	Radiotracer R&D in Nuclear Medicine and Neurosciences	MED
NIDA	PET Studies of Brain Dopamine in Cocaine Abusers	MED
NIAAA	Dopaminergic Brain Function in Alcoholics	CHEM
NIGM	Nondiamagnetic Agents in In-Vivo 23NA & 2H2 MR	MED
NIDA	Pharmacokinetics of Psychostimulants & Reinforcement	CHEM
NIH	PET Investigations of Neurotransmitter Interactions	CHEM
NIH	Auger Electron Therapy: Gadolinium & Thermal Neutrons	MED
NIDA	PET Studies of Brain Dopamine in Cocaine Abusers	MED
NIDA	Pharmacokinetics of Psychostimulants & Reinforcement	MED
NIMH	PET Investigations of Neutrotransmitter Interactions	MED
NIH	1 HNMR Chemical Shift Imaging in Temporal Lobe Epilepsy	MED
NIH	Estimation of Synaptic Dopamine using PET & SPECT	MED
NIH	Modulation of Neutrons Matter Release by Cannabinoids	MED
NIH	Dopaminergic Brain Function in Alcoholics	MED
NIH	Structure Function Relations in Botulinum Neurotoxin	BIO
	DEPARTMENT OF STATE	
AID	International Safeguards Project Office POTAS	DAT
AID	Lisbon Project	DAT
	ENVIRONMENTAL PROTECTION AGENCY	
EPA	Barrier Materials Evaluation of Waste Forms Dumped in the Kara and Barents Seas	DAT
EPA	NY/NJ Harbor Sediment Decontamination Tech. Demonstration: Phase II Pilot Scale	DAS
EPA	Program Plan from BNL for 1998 Interagency Agreement between EPA & DOE	DAS
EPA	MARKAL-MACRO Training & Analyses	DAT
EPA	Murmansk Initiative & Related Waste Management Projects in the Former Soviet Union	DAT
	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	
NASA	Representation of Aerosol Microphysics in Regional to Global Scale Models	DAS
NASA	Validation of the SeaWiFs Atmospheric Correction Scheme using Measurement of Aerosol Optical Properties	DAS
NASA	Reaction Pathways & Thermodynamic Studies of Atmospheric Reactions	DAS

Table 23 - FY 99 WORK FOR OTHERS BY PROJECT

FUNDING AGENCY	TITLE	DEPARTMENT
NASA	Genetic and Epigenetic Effects Produced by High Energy Heavy Ions	MED
NASA	Genetic and Epigenetic Effects Produced by High Energy Heavy Ions	BIO
NASA	Feasibility Study-Heavy Ion Beam Facility for Radiation Health Research at AGS Booster	AGS
NASA	Booster Applications Facility	AGS
NASA	Heavy Ion Beam for SEU Studies & Radiation Effects Research	AGS
NASA	Interpretation of Light Observations using an Eulerian Aerosol Model	DAS
NASA	Phase Transformations in Stratospheric & Upper Tropospheric Aerosols: Lab Studies of Single Particles	DAS
NASA	DNA Lesion Clusters in Space Radiation Damage	BIO
NASA	Germ Cell Mutagenesis in Medaka Fish Following Exposure to Heavy, High Energy Cosmic Ray Nuclei	BIO
	NATIONAL SCIENCE FOUNDATION PROGRAM 40	
NSF	DOE National Teacher Enhancement Project	DO
NSF	Protein Data Bank Macromolecular Structure Data Base	BIO
NSF	U.S.-Japan Joint Seminar: Probing Hadron Structure with Polarized Photons	PHY
	VARIOUS MISC. FEDERAL AGENCIES - PROGRAM 40	
DOT/FAA	FAA IAG Working Group on Airport Vulnerability Assessment Project	DAT
PETC	Clean Coal Fossil Fuels and Energy Efficiency	DAS
DOI/NPS	Tracer Study of Long Range Transport in Support of BRAVO	DAS
DOE NN-30	Safeguards Analysis	DAT
	PRIVATE ENTITIES	
US Civilian R&D Foundation	Fellowship for Dr. Ne	CHEM
ALS Association	Studies of the Activities of ALS Mutant SOPs Using Pulse Radiolysis Techniques	CHEM
Children's Brain Tumor Foundation	Unidirectional Microbeam Radiation Therapy of Children's Brain Tumor using Synchrotron X-rays	MED
Charles A. Dana Foundation	Cerebral Metabolism in Ketosis and Epilepsy: 1H and 31P Spectroscopic Study at 4.1T	MED
Multiple Sclerosis Society	H Spectroscopic Imaging of Multiple Sclerosis	MED
Applied Genetics, Inc.	DNA Repair Enzyme-Liposomes: Human Skin Cancer Prevention	BIO
SUNY-SB	Vaccine Intervention for Lyme Borreliosis	BIO
KGL Inc.	Investigation to Assess the Influence of Topical Treatment with a Hydroxy Acid on UUB-Induced Thymine Dimers in Human Skin	BIO

Table 23 - FY 99 WORK FOR OTHERS BY PROJECT

FUNDING AGENCY	TITLE	DEPARTMENT
DuPont	Development of Structural Models of Plant Soluble Fatty Acid Desaturase as a basis for Rational Design of Desaturase Double Bond Positional Specificity.	BIO
NYU (NIH)	PET in Schizophrenia	CHEM
NYU (NIH)	PET in Schizophrenia	CHEM
DuPont	Catalytic Production of Organic Chemicals Based on New Homogeneously Catalyzed Ionic Hydrogenation Technology	CHEM
Univ. Minnesota	FACE Facility at Cedar Creek	DAS
North Carolina State Univ.	Diagnostic Analysis of the Nashville Data	DAS
Electro Energy	Preparation and Characterization of Metal Hydride Electrode Materials for Bipolar Batteries	DAT
Concurrent Tech.	Advanced Zinc Phosphate Conversion Coatings for Electrogalvanized Steel	DAS
Woods Hole (NSF)	Analysis of Acoustic Data Gathered during the SHEBA Project	DAS
SUNY-SB	Geochemical Tracers in the North Water Polyna	DAS
Woods Hole (NSF)	GLOBEC: Collection of Shipboard ADCP Data & the 1st year of the NE Channel & Scotian Shelf Water Cross-Over Moving Array	DAS
Penn State University	Investigations of Factors Determining the Occurrence of Ozone and Fine Particles in the North Eastern USA	DAS
St. Luke's (NIH)	Medical Applications Accuracy Neutron Activation	MED
Metabolic Tech.	3-Methylhistidine Kinetics as an Indicator of Muscle Mass and Metabolism	MED
JAERI	A Study of Medium and High Energy Proton Nuclear Cascade Process in Context of Accelerator Based....	DAT
PWR Reactors Nuclear Fuel-Tokyo	A Study of High Level Radiation Waste Material Transmutation Using an Accelerator	DAT
Crown Communications	Analytical Support, Methods, Development & Review for FAA	DAT
Power Reactor & Nuclear Fuel	Joint Study of Improved Safeguards Methodology Using No Notice Randomized Inspection	DAT
Cornell Univ.	CADD-based Expert System for Passive Snow Control	DAT
Science Digital Visions	Registry System for Accessing NNDC Nuclear Data Bases	DAT
International Resource Group Ltd.	Energy, Environment & Economic Modeling & Policy Analysis	DAT
NUCON Systems, Inc.	Evaluation of the Radiation Stability of Ceramics	DAT
American Bureau of Shipping	Human Factors Engineering Guidance Development for Merchant Vessels	DAT
DuPont	Flame Acceleration and Detonation Experiments in Methane-Air Mixtures at Elevated Temperatures	DAT
Science Engineering Associates	Perfluorocarbon Tracer Testing at the Science Engineering Test Site	DAT
Enconet Consulting	Risk Informed Applications for Nuclear Power Plants	DAT

Table 23 - FY 99 WORK FOR OTHERS BY PROJECT

FUNDING AGENCY	TITLE	DEPARTMENT
Radkowski Thorium Corp	Radkowski Thorium Fuel Project	DAT
SCRAM Tech.	Polyplanar Optic Display Interactivity	DAT
Korean Atomic Energy Res. Inst.	Fission Product Neutron Data Evaluation	DAT
Cornell Univ.	Tort Law Database	DAT
University Tokyo	Japan Cooperative Program on Neutron Scattering	PHYS
Ev Products Div of II-IV	Development of Multi Channel ASICs for CdZnTe Gamma Ray Detector Arrays	INST.
Symbol Tech. Inc.	Microcircuits & Sensors for Portable, Low-Power Data Collection & Transmission	INST.
Medical Univ. of S. C.	The Environmental & Health Risks Associated with Accelerator Production of Tritium	DAS
Johns Hopkins University	Multi Institutional NSCORT Consortium in Radiation Health	MED
Public Works & Government Services, Canada	Assistance to AECB in Developing a Regulatory Position on Severe Accident Management for Existing Reactors	DAT
Korean Atomic Energy	Technical Assistance to KAERI on Low Power & Shutdown PSA of YGN 5 & 6	DAT
University of Valencia	Pilot Study & Guidance for Technical Specification Improvement for Spanish Nuclear Power Plants	DAT
DuPont	Catalytic Production of Organic Chemicals Based on New Homogeneously Catalyzed Ionic Hydrogenation Technology	CHEM
Various Non Profit Agencies	A Center for International Security Studies	DAT
KGL Inc.	Photo-irradiation Study of the Effect of Topical Imiquimod 5% Cream on Sunburn Cell….	BIO
LILCO	Determination of Gas Flow Rates at LILCO Gas-Fired Power Stations	DAS
Con Ed	NASTRO-NE Site @ BNL	DAS
LILCO	Cation Exchange Adsorbents & High Performance Cements from Ash & Sludge Wastes	DAS
EPRI	Remediation of Soils Contaminated with Lead Paint	DAS
EPRI	NARSTO-NE Ozone Formation in the NY City Urban Area Plume	DAS
Con Ed	Equipment for Rapid Cable-Leak Locating and Detecting Capabilities	DAS
Con Ed	Demonstration & Characterization of MagPipe. Magnetic Instruments for Determining the Location, Orientation, and Depth of Pipe Joints	DAT
	STATE AGENCIES & LOCAL GOVERNMENTS	
NYSERDA	Oil-Fired Heating System Development & Demonstration	DAS
Suffolk County Dept. of Health	Brown Tide Monitoring Network	DAS

Table 23 - FY 99 WORK FOR OTHERS BY PROJECT

FUNDING AGENCY	TITLE	DEPARTMENT
South Coast Air Quality Management District	Tracer Dispersion Study of Shipping Emissions During SCOS-NARSTO	DAS
Suffolk County	Dissolved Organic Nitrogen & Brown Tide Blooms in L.I.'s Coastal Waters	DAS
Mass. Water Resource Authority	Boston Harbor Project/Waste Water Treatment on Deer Island	DAT
	OTHER DOE CONTRACTORS	
Battelle-PNNL	Various Battelle - PNL Work Orders for Continuation of LISBON Project	DAT
Battelle-PNNL	Participation and Scientific Management of ARM Program	DAS
Savannah River	MC&A Studies for SR Facilities & Review of Documents	DAT
Idaho Operations Office	Molecular Analysis of Carbohydrate Regulation in Loblolly Pine	DAS
ORNL	Design & R&D of Accumulator Rings of Rapid Cycling Synchrotrons & High Energy Beam transport Systems	AGS
Idaho Operations Office	Biochemical Processes to Remove Undesirable Elements From Geothermal Operations	DAS
Albuquerque Office	Proton Radiography Experiment	AGS
Albuquerque Office	Enhanced Surveillance, Phytoremediation & Evaluation of Risks w/ Re-distribution. - Chernobyl (DSWA)	DAT
Idaho Operations Office	Geothermal Heat Pump Grouting Materials	DAS
Sandia	Source-Term Calculations for WIPP Performance Assessment	DAS
Idaho Operations Office	Silica Precipitation by Thermophilic Bacteria in Hot Springs	DAS
Albuquerque Operations	Management of Spent Nuclear Fuel in Kazakstan, Russia	RO
Albuquerque Office	Development of Submillimeter Microwave Spectrometers for Materials Analysis & Other Applications	PHY
Albuquerque Office	Linear Ion Source	PHY
Albuquerque Office	Improved Automated Processing of Mbp Scale DNA Sequencing	BIO
Albuquerque Office	Surveillance for Comprehensive Asset Tracking Technology	DAT
Albuquerque Office	Technology Advances to Reduce Emissions from Fossil Fuel Power Plants	DAT
Albuquerque Office	Thorium Fuel Concept	DAT
Albuquerque Office	Study of Local Magnetic Flux Distribution Related to Transport Properties of High-Tc BSCCO Superconducting Practical Tapes	DAT
Albuquerque Office	Development of Algorithms & Methods for the Recognition & Display of Hierarchical Repeat Structures in DNA Sequences	BIO
Albuquerque Office	Retargeting of Adenovirus for In-Vivo Gene Therapy	BIO
Albuquerque Office	Development of Sensitive & Specific Rapid Diagnostic Tests for Lyme Borreliosis in Russia	BIO
Sandia	Dynamics of Dislocations Near Interfaces in Thin Metal Films	PHY
FERMI	Design, Construction and Installation of the Forward Pre-shower Detector for the D Zero Upgrade Project	PHY
Lockheed Martin	Technical Support for EPA/DOE Environmental Technology Verification Program	DAT

Table 23 - FY 99 WORK FOR OTHERS BY PROJECT

FUNDING AGENCY	TITLE	DEPARTMENT
Lockheed Martin	Biological Warfare Response Improvement Program	DAT
ORNL	EM Mixed Waste Focus Area	DAT
Sandia	Cement Research Project	DAS
ORNL	Spallation Neutron Project	AGS
LLNL	SCOUNGATRON Project	AGS
Sandia	SEU Testing	AGS
Battelle-PNNL	Accelerator Transmutation of Waste Workshop	DAT
FETC	Krakow Clean Coal Fossil Fuels & Energy Efficiency Program	DAS
University California	Development. of Radioactive Beam Capability at the 88-Inch Cyclotron	CO
Sandia	Use of High Temperature, CO2 Resistant Cements Developed at BNL	DAS
Oak Ridge Ops. Office	Alternate Site Identification & characterization for the National Spallation Neutron source Project	DO
Lockheed Martin	Develop Animal Models, Prepare Rhenium-188 Labeled Stents and Evaluate the Histological Properties for ORNL	MED
Sandia	Catalysis Research	CHEM
Lockheed Martin	Assembly of a Control System for one 24 Valve Ring	DAS
FERMI	Fabricate & Deliver 4" S1 Wafer with Metalized Pixel Pattern	IO
Sandia	UAV Measurement Study	DAS
Argonne	Fabricate 3D Wire Detector 20cms x 20cms Area	IO
Lockheed Martin	Provide Depth Profiles of Vacancy Related Defects in Ion Implanted Silicon Samples from ORNL	DAS

Cooperative Research and Development Projects

Table 24 - CRADA PROJECTS

SPONSOR	TITLE	DEPARTMENT
Advanced Imaging Research Inc.	Passive Shim Array for Improved Static Field Homogeneity in Magnetic Resonance Imaging of the Human Head	CHEM
Aquila Technologies	Advanced surveillance for Comprehensive Asset Tracking Technology	DAT
BioCat, Inc.	Nanophase Supported Metals as Catalysts for Deep Hydrosulfurization (HDS) of Crude Oils	DAS
Brookhaven Technology Group, Inc.	Development of a High Current, High Gradient, Laser Excited, Pulsed Powered Electron Gun	IO
Consolidated Edison Company	Equipment for Rapid Cable-Leak Locating and Detecting Capabilities	DAS
Cotton Incorporated	Improving Cotton Fiber Quality and Yield	BIO
CTI, Inc.	Non-Invasive Blood Radioactivity Monitor for Quantitative PET Imaging Studies	CHEM
Diatide, Inc.	Development of Tin-117m Stannic DTPA for the Therapy of Cancer in Bone	MED
DuPont Agricultural Products	Development of Structural Models of Plant Soluble Fatty Acid Desaturase As A Basis for Rational Design of Desaturase Double B and Positional Specificity	BIO
DuPont Company	Catalytic Production of Organic Chemicals Based on New Homogeneously Catalyzed Ionic Hydrogenation Technology	CHEM
ElectroEnergy, Inc.	The Preparation and Characterization of Metal Hydride Electrode Materials for Bipolar Batteries	DAS
Gas Research Institute	Design and Manufacture of a Prototype Rapid Concrete Cutter Device for Opening of Concrete Pavements above Subterranean Gas Pipelines	DAT
Gould Electronics, Inc.	Development of New electrolyte and electrode Materials for rechargeable Lithium Batteries and In-situ Techniques for Battery Material Studies	DAS
II-VI, Inc.	Development of Multi-Channel ASICs for CdZnTe Gamma Ray Detector Arrays	IO
International Resources Group Ltd.	Energy, Environment and Economic Modeling and Policy Analysis	DAT

Table 24 - CRADA PROJECTS		
SPONSOR	**TITLE**	**DEPARTMENT**
Metabolic Technologies, Inc.	3-Methyl Histadine Kinetics as an Indicator of Muscle Mass and Metabolism	MED
NYSERDA	Oil Fired Heating System Development and Demonstration	DAS
Oncogene Research Products	Development of Immunological Reagents for Analysis of DNA-Damage Responses in Human Cells	BIO
Oxford Superconducting Technology	Development of Buffer Layers Suitable for Thick Superconducting YBCO Layers By A Post Deposition Annealing Process	DAS
PhytoWorks	Aquatic Plants for Phytoremediation of Toxic Metals and Radionuclides in Sediment	DAT
PPG Industries, Inc	An Investigation of the Chemistry of Lead During Undermining of Coatings on Steel	DAS
Radkowsky Thorium Power Corp.	Radkowsky Thorium Fuel Project	DAT
Schering AG	Development of a Non-Iodine Based Radiographic Contrast Agent and a Complementary Monochromator for CT and Planar X-ray Imaging Sources	MED
SCRAM Technologies, Inc.	Polyplanar Optic Display Interactivity	DAT
SmithKline Beecham Corp	Gene Expression and Identification of Gene Function in the Genome of Streptococcus pneumoniae	BIO
Standard MEMS, Inc.	High Aspect Ration Microfabrication Using UV Lithography	IO
Symbol Technologies, Inc	Microcircuits and Sensores for Portable, Low-Power Data Collection and Transmission	IO
Symbol Technologies, Inc.	Microcircuits and Sensors for Portable, Low-Power Data Collection and Transmission	IO

BSA Patent and Licensing Information

Table 25 - BSA PATENT PORTFOLIO

Technology Field	Inventions in Portfolio	Inventions Licensed	Inventions Commercialized
Molecular Biology	20	10	4
Medical Devices	9	0	0
Pharmaceuticals	7	3	1
Optics	13	11	1
Instrumentation	14	4	3
Materials	9	2	0
Environmental Remediation	15	5	3
Energy Production	3	2	0
Total	**90**	**37**	**12**

Table 26 - PRODUCTS MARKETED UNDER LICENSES FROM BNL

PRODUCT	DEPARTMENT
Apparatus and Method for Biological Purification of Wastes	DAS
T7 Gene Expression System, Vectors and Protein Products Produced with the T7 System	BIO
Red Blood Cell Labeling Kit for Selectively Labeling Whole Blood with Tc-99m	MED
Recombinant Plasmids for Encoding Restriction Enzymes Dpn I and Dpn II of Streptococcus Pneumoniae	BIO
Fast Repetition Rate Fluorometers and Method for Measuring Fluorescence and Photosynthetic Parameters	DAS
Surface Profiling Interferometers for Accurately Measuring Irregularities in the Surfaces of Mirrors and Lenses	IO
Cytoplasmic Bacteriophage Display System	BIO
Autogenes Encoding RNA Polymerases	BIO
Polyethylene Encapsulation of Radioactive and Mixed Wastes	DAT
Asbestos Remediation	DAS

Table 27 - BSA Licensing Revenue ($1000)

	FY 96	FY 97	FY 98	FY 99
Gross Revenue	889	1342	1656	2771
Net Revenue	488	992	1196	2136

Appendix D - Multi-Program Energy Laboratory Facility Support Project Summaries

The following proposed projects are based on BNL's anticipated / expected requirements, developed to allow the Laboratory to meet its mission and critical outcomes.

Proposed Projects - General Purpose Facility (KG-01)

Roofing Phase II (FY01): BNL has 2, 980,000 square feet of built-up roofing. A 1989 study concluded that over half of the roof area was in poor condition or had failed, and needs replacing. Roof replacements compete with other needs, and the backlog of these projects continues to grow. This project would provide funds to replace roofing systems. There is a current backlog of over $7,000,000 for built-up roofs that are beyond their useful life and in which have various components have failed.

Maintenance cannot further prolong the life-cycle of these roofs; deterioration from normal aging, and deterioration from deferred maintenance has increased failures.

Electrical System Modifications - Phase II (FY01): This project continues the progress made in Phase I by replacing old deteriorating underground electric 13.8 kV cables, and adding supporting underground ductbank. The existing cables have outlived their useful life and will be replaced with solid dielectric shielded cables. Based on condition assessments, other electrical equipment including transformers and switchgear, will be replaced or retrofitted to extend its useful life.

Central Steam System Rehabilitation (FY 02): The Central Steam System Rehabilitation project will replace deteriorated portions of BNL's underground steam-distribution system and extend the service life of the Central Steam Facility's (CSF) largest boiler. The Central Steam System provides steam for heating, humidification, and process cooling to the majority of BNL's facilities. This project is required to ensure a reliable, safe steam-supply to the majority of programmatic facilities in the core of the site. Major sections of the steam-distribution system were constructed in the late 1940s and early 1950s and are nearing the end of their useful life. This project continues BNL's program to correct code- and operational-safety deficiencies in its system.

Department of Advanced Technology Building - Phase I (FY03): The Department currently occupies all or part of 10 buildings, most of which are either World War II-era barracks, wooden modular buildings, or old permanent-type constructions. This decentralized distribution of staff in old, ineffective buildings is demoralizing and decreases effective interchanges between staff members. Administering and managing the Department is inefficient due to the distances between buildings. Consolidating the staff would improve the working relationships, efficiency, and productivity.

The proposed Phase I building would be located near existing permanent structures which house the major portion of experimental equipment and facilities used

by the Department. This phase would consolidate a significant part of the Department's administration, management, scientific, engineering and experimental staff, and result in reduced maintenance costs for the associated space.

Roofing Phase III (FY04): A 1989 roofing study concluded that over half of the roof area studied was in poor to failed condition, and needs replacing. The replacements complete with other needs, and the backlog of these projects continues to grow. This project will continue to provide funds to replace roofing systems to reduce this backlog. Further maintenance cannot be expected to further prolong the life-cycle of these roofs.

High-Speed Fiber-Optic Infrastructure - Phase I (FY04): The National Information Infrastructure is now a reality. The late 1990s saw millions of commercial entities embrace the Internet as a medium for conducting business. The World Wide Web browser sparked a revolution that has radically increased the demand for network bandwidth. Network providers are scrambling to increase their throughput and remove bottlenecks. The traffic on the Internet is increasing so rapidly that it cannot be predicted confidently from year-to-year and video teleconferencing over the Internet still is not widely used.

The Laboratory's information infrastructure is, and has historically been, driven by near-term Department centered projects that prioritized initial cost above all else. The resulting network is very labor-intensive. The only way to properly anticipate future requirements on BNL's network is through a consistent, long-term plan that does not require each allocation of funds by each department or division. This project will be a major step toward meeting the Laboratory's communications needs well into the future.

Central Steam System Rehabilitation - Phase II (FY04): BNL's Central Steam System provides steam for heating, humidification and cooling of BNL's programmatic facilities. The major sections of the steam-distribution system were constructed in the late 1940s and early 1950s and are nearing the end of their useful life. This project continues upgrades to the Central Steam System by replacing deteriorated portions of the underground steam-distribution system, and extending the system to buildings currently serviced by old local boilers that need replacement. This project will ensure a reliable, safe steam-supply to programmatic facilities.

Proposed Projects - ES&H Support (KG-02)

Ground and Surface Water Protection (FY01): This project will implement several upgrades to systems and facilities needed to comply with Suffolk County Sanitary Code Article 12, and protect Long Island's sole-source aquifer. The upgrades will include eliminating non-compliant discharges, reducing non-contact cooling water, eliminating radiologically contaminated cooling systems, and installing secondary containment and leak detection on several systems containing hazardous fluids.

Life Safety Code Modifications - Phase I (FY02): Sixteen buildings will be upgraded to comply with National Fire Protection "Life Safety Code" NFPA 101. This

project will bring the facilities into compliance and make them safer for their occupants. Upgrades include modifying building egress, stairwells, fire walls, sprinkler systems, emergency lighting, smoke detector systems, and other related systems.

Halon System Replacement (FY03): This project encompasses replacing Halon Systems to meet the environmental mandates of the Clean Air Act (1990). The Montreal Protocol and 1993 amendments require the phase-out of halon systems. Through this project BNL will decommission and replace these systems with acceptable alternatives to maintain compliance with DOE's Fire Protection Standards. The Laboratory has less than 100 halon systems. The replacement systems will include sprinkler systems, and very-early-warning detection (VESDA) or carbon dioxide systems for unoccupied areas. Halon fire extinguishers also will be replaced with suitable alternatives.

Life Safety Code Modifications - Phase II (FY04): BNL will upgrade additional buildings to comply with National Fire Protection "Life Safety Code" NFPA 101. This project will continue to bring the facilities into compliance and make them safer for the occupants. The upgrades include modifications to building egress, stairwells, fire walls, sprinkler systems, emergency lighting, smoke detector systems, and other related systems.

Appendix E - Other Site Information

Annual Participation in the Science Education Program

Brookhaven National Laboratory Staff Composition

Brookhaven National Laboratory Equal Employment Opportunity

Subcontracting and Procurement

Small and Disadvantaged Business Procurement

Table 28 - Annual Participation in Science Education Programs

Post-secondary Programs	FY1997 Total	FY1997 Minority	FY1997 Female	FY1998 Total	FY1998 Minority	FY1998 Female	FY 1999 Total	FY 1999 Minority	FY 1999 Female
UNIVERSITY PROGRAMS									
Nuclear Chemistry Summer School	13	1	10	12	0	5	13	1	8
Summer Students/ERULF	36	17	5	45	7	22	50	17	20
SERS/ERULF Semester	17	1	9	14	3	10	20	7	3
Special Groups: BSP									
Student	0	0	0	2	2	1	1		
Faculty	1	0	1	0	0	0	0		
Special Groups Gallaudet									
Student	4	1	1	1	0	0		**Not Offered**	
Faculty	0	0	0	0	0	0			
NSLS/HFBR Faculty-Student Teams		**Not Offered**			**Not Offered**			**Not Offered**	
Graduate School Fair (est.)		**Not Offered**			**Not Offered**			**Not Offered**	
COMMUNITY COLLEGE TA									
CCHP Summer Students/CCI	11	11	4	10	10	2	25	16	13
Faculty	0	0	0	0	0	0	1	1	
Semester Co-Op	5	5	5	8	3	1	0		
Northeast Consortium (SUMS) and CC Mini-semesters	12	3	12	17	17	6	16	13	9
TOTAL	**99**			**109**			**126**		

Table 28 - Annual Participation in Science Education Programs (continued)

Pre-college Programs	FY1997 Total	FY1997 Minority	FY1997 Female	FY1998 Total	FY1998 Minority	FY1998 Female	FY 1999 Total	FY 1999 Minority	FY 1999 Female
SCHOOL DISTRICT TA (SDTA)									
Community Summer Science (HS)	40	6	16	40			40	3	17
NYS Summer Environmental Institute (HS)		**Combined with CSSP**			**Combined with CSSP**			**Combined with CSSP**	
Semester Research Interns	3	0	3	7	0	5	1		1
Women in Science (HS)	30	1	30	29	0	29	28		28
DOE Science Bowl (HS)		**Not Offered**			**Not Offered**			**Not Offered**	
Saturday Science (JHS)	0			0			0		
Magnets-to-Go (5-6)		**Not Supported by OEP**			**Not Supported by OEP**			**Not Supported by OEP**	
Science Fair (K-6)	760			650			747		
Visiting Scientist/Scientists in Residence	150			150				**Not Funded**	
NYS Mentoring Program	40			20			20		
SDTA Special Services (teacher/admin)				77			250		
SDTA Special Services (students)				220			25	8	25
MINORITY PIPELINE (SUMS)									
Northeast Consortium		**Not Supported by OEP**			**Not Supported by OEP**			**Not Supported by OEP**	
Environmental Education Outreach		**Not Offered**			**Not Offered**			**Not Offered**	
MHSAP/NIH Summer Apprenticeships	28	28	18	30	30		29	29	14
NIH Summer Research Apprenticeship		**Not Offered**			**Not Offered**			**Not Offered**	
Introduction to Computers		**Not Supported by OEP**			**Not Supported by OEP**			**Not Supported by OEP**	
SUMS HS Mini-semester		**Not Offered**			**Not Offered**			**Not Offered**	
SUMS Exploration Days		**Not Offered**			**Not Offered**			**Not Offered**	
TOTAL:	**1051**			**1223**			**1140**		

Table 28 - Annual Participation in Science Education Programs (continued)

	FY1997			FY1998			FY 1999		
	Total	Minority	Female	Total	Minority	Female	Total	Minority	Female
TECHNICAL ED/MST INT (PAST)									
MAGLEV Tech Ed Consortia (approximate)	300			300			300		
Technology Educator's Workshops	30	1	0	30			30		
MST Conference Workshops	40			40			40		
Annual BNL Systemic conference		**Not Offered**			**Not Offered**			**Not Offered**	
TEACHER ENHANCEMENT (PTEP)									
Annual BNL Systemic Conference (SITE)		**Not Offered**		15				**Not Offered**	
NYU Teacher Res. Association and	3	3	2	2	2	0	3	2	2
DOE Teacher Res. Association (TRAC)	1	0	0	2			**Combined with NYR Teacher Res. Association**		
NSF/DOE National Teacher Enhancement (NTEP)	30	5	23	6	1	4	3	0	3
NSF Elementary MST (MSTe)	61	6	47	61	6	47	180	35	130
HS Teachers' In-Service Course							20		
SUMS MHSAP Internships		**Not Offered**			**Not Offered**			**Not Offered**	
DOE/NSF Co-op Appointments				6			0		
TOTAL	**465**			**462**			**576**		

Table 29 - Brookhaven National Laboratory Staff Composition
Effective November 1999

	PhD		MS/MA		BS/BA		OTHER		TOTAL	
	#	%	#	%	#	%	#	%	#	%
PROFESSIONAL STAFF										
Scientists	458	74.6	77	12.5	71	11.6	8	1.3	614	20.3
Engineers	99	19.9	187	37.6	176	35.3	36	7.2	498	16.5
Management & Administrative	38	9.5	95	23.8	123	30.8	144	36.0	400	13.2
Other Professional	6	1.8	11	3.3	58	17.4	259	77.5	334	11.0
SUPPORT STAFF										
Technicians	0	0.0	5	1.3	49	12.4	342	86.4	396	13.1
All Others	0	0.0	9	1.2	55	7.0	718	91.8	782	25.9
LABORATORY TOTAL	**601**	**19.9**	**384**	**12.7**	**532**	**17.6**	**1507**	**49.8**	**3024**	**100.0**

Table 30 - Brookhaven National Laboratory Equal Employment Opportunity Effective November 1999

Occupational Codes	Total		Minority Total		Minority									
					White		Black		Hispanic		Native American		Asian/Pacific Islanders	
Gender	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Officials/Managers														
	432	83	36	15	396	68	8	5	6	2	0	0	22	8
	83.9%	16.1%	7.0%	2.9%	76.9%	13.2%	1.6%	1.0%	1.2%	0.4%	0.0%	0.0%	4.3%	1.6%
Professional Staff Scientists & Engineers	751	133	133	43	618	90	10	4	16	6	0	0	107	33
	85%	15%	15%	4.9%	69.9%	10.2%	1.1%	0.5%	1.8%	0.7%	0.0%	0.0%	12.1%	3.7%
Management & Administrative	281	166	30	23	251	143	13	12	4	5	1	1	12	5
	62.9%	37.1%	6.7%	5.1%	56.2%	32%	2.9%	2.7%	0.9%	1.1%	0.2%	0.2%	2.7%	1.1%
Technicians	364	32	40	4	324	28	18	3	15	0	3	0	4	1
	91.1%	8.1%	10.1%	1.0%	81.1%	7.1%	4.5%	0.8%	3.8%	0.0%	0.8%	0%	1.0%	0.3%
All Other														
	442	340	106	96	336	244	69	74	25	18	5	3	7	1
	56.5%	43.5%	13.6%	12.3%	43.0%	31.2%	8.8%	9.5%	3.2%	2.3%	0.6%	0.4%	0.9%	0.1%
Totals	**2270**	**754**	**345**	**181**	**1925**	**573**	**118**	**98**	**66**	**31**	**9**	**4**	**152**	**48**
	75.1%	**24.9%**	**11.4%**	**6.0%**	**63.7%**	**18.9%**	**3.9%**	**3.2%**	**2.2%**	**1.0%**	**0.3%**	**0.1%**	**5.0%**	**1.6%**

Table 31 - Subcontracting and Procurement Dollars in Millions-Obligated [1]	Actual FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY2002
Subcontracting and Procurement from:				
Universities	6.9	5.8	6.0	6.2
All Others	121.6	125.3	133.2	137.9
Transfers to other DOE Facilities	5.7	11	11	11.4
Total External Subcontracts and Procurement	134.2	142.1	150.2	155.5

(1)Show total dollars obligated within each fiscal year.

Table 32 - Small and Disadvantaged Business Procurement Dollars in Millions – Budget Authority [1]	Actual FY 1999	Estimated FY 2000
Procurement from S&DB	9.9	6.9
Percent of Annual Procurement	9.0	5.0

(1) Show total dollars obligated within each fiscal year.